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Technology and innovation diffusion: A workers' perspective

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A thesis submitted to the Faculty of Graduate Studies and Research in partial fulfillment of the requirements of the degree of Master of Architecture (M. Arch)

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Abstract:

Construction workers are an important resource in a country where housing is a desperate need and an unaffordable proposition for millions and where housing built by the organized sector serves only a marginal population. Much therefore depends on the workers' know how and skills to produce affordable and quality housing. In a country like India, where traditional home building technology is being fast replaced by building technology from the west, it is essential to know how and to what extent is this change imbibed by these producers of housing- the construction workers. How do people become construction workers? How and where do they learn and train? What are their sources of new technology? What are their systems and conditions of operation? These questions become significant if this resource has to be trained and deployed not only for improving quality of construction but also to actively involve them in the alleviation of the state of technology, diffusion of much needed technology innovations and development of a powerful and effective grass root level resource to upgrade the housing conditions of the country's poor. This dissertation pursues these issues with the aid of a study of skilled construction workers in the Pune region of India. It ends with a conceptual model to help overcome some drawbacks of the present system and points to other related issues that need immediate consideration in the interest of overall development of the home building industry.

Resumé

Les travailleurs de la construction sont très importantes dans un pays avec des sevères problèmes de logement, un pays dont les services de construction organisés ne deservent q'une population marginale et ou devenir proprietaire c'est n'est pas une option abordable pour des milliers de personnes. Alors, la production des logements abordables et de qualité, va depender de l'habilité des maçons. Dans un pays comme l'Inde, où la technologie de la construction est rapidement remplacée par des techniques provenantes de l'Ouest, c'est essentiel de savoir comment et dans quelle messure, sont les maçons ceux qui proposent le change. Comment devient-on un maçon? Comment et où obtienent-ils leur entraînement? Quelles sont leurs resources de technologie? Quelles sont leur systèmes et conditions d'opération? Ces questions deviennent importantes si les resources doivent être entraînés et diffusés, pas seulement pour ammélliorer la qualité des constructions mais aussi pour les faire participer de l'ammélioremente de la situation de la technologie, de la difussion des innovations technologiques, dont il y a une grande necessité, et le development d'un puissant resseau pour l'ammélioremente du logement des pauvres. Le propos de cette these c'est l'étude des maçons qualifiés de la region de Pune. Ça finie avec un model conceptuel pour aider a supérer des problèmes du système de transfert de technologie actuel et avec une discussion des autres aspectes qui concernent le development de l'industrie du logement.

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Contents

Abstract I

Resumé II

Acknowledgements III

Contents IV

Chapter 1:
Introduction 1

1.1 Introduction

1.2 Research Question

1.3 Hypothesis

1.4 Rationale

1.5 Methodology

1.6 Scope and Limitations

1.7 Dissertation layout

1.8 Definitions

Chapter 2 :
Literature review : Factors affecting innovation diffusion 17

2.1 Definitions

2.2 Factors affecting diffusion

2.3 Diffusion and the building industry:

2.4 Diffusion studies 5

2.5 Models of Diffusion

2.6 Afterword

Chapter 3:
Building trades in the Pune region 42

3.1 State of Building Technology in India:

3.2 Construction Activity in the Pune region

3.3 Construction workers

3.4 Producers of Housing

3.5 Trade 1: Concreting

3.6 Trade 2: Masonry

3.7 Trade 3: Carpentry

3.8 Trade 4: Fabrication

3.9 Trade 5: Flooring

3.10 Trade 6: Electrification and Plumbing

Chapter 4:
Classified data, observations and inferences 73

4.1 Sample profile

4.2 Analysis of data and recording of observations

4.3 Personal and family background

4.4: Professional training

4.5 Comprehension and allied skills

4.6 Work team

4.7 Entry into and choice of profession

4.8 Employment

4.9 Source of innovation

4.10 Acquisition and use of innovations

4.11 Further classification and correlation

Chapter 5:
Tradewise discussion 101

5.1 Concreting
5.2 Masonry
5.3 Carpentry
5.4 Fabrication
5.5 Flooring and Painting
5.6 Electrification and Plumbing

Chapter 6:
A discussion with field professionals 110

6.1 Construction Workers
6.2 Architects and engineers
6.3 Work system and culture
6.4 Innovations
6.5 The Public Works Department System
6.6 Builder- contractor system

Chapter 7:
Diffusion and Workers- Present and Future 120

7.1 Technology and innovation diffusion
7.2 A conceptual model

Cited Bibliography 127

Appendix 129

Chapter 1: Introduction

1.1 Introduction:

Diffusion of modern knowledge into traditional societies has been the greatest challenge in the developing countries in this century. On the one hand, industrialization, mechanization and its sophistication are becoming realities of human enterprise the world over, while on the other hand, traditional systems, cultural values and customs, and conservative attitudes dominate most societies and their psyches. But the modern and traditional worlds are not watertight compartments. In fact, they deeply influence each other. Knowledge flows from both sides to both sides. But it is the flow of knowledge and introduction of systems from the modern to the traditional world that presents conflicts, poses difficulties and necessitates review of the situation time and again. Construction industry- especially the home building industry in developing countries has been the forte of traditional craftsmen and skilled workers. India is an excellent example of a full fledged, mature and highly evolved traditional home building industry. Till date, except for a small percentage of architects-engineers built housing, majority of the housing stock is produced by traditional construction workers- masons, bricklayers, carpenters, tile layers etc. But traditional industry does not imply a segregation of these workmen, their tools, techniques, and materials of construction from those of the modern world. A slow but sure absorption of modern techniques and materials- innovations in every sense- has taken place. In some cases, it has been so smooth and total that modern processes have become a part of the vernacular. The wide spread use of reinforced concrete, the familiarization with the basic power tools or the introduction and

stabilization of entirely new professions of plumbers and electricians are obvious examples of adoption to changing times and technology.

A wide gap exists in the housing produced along with the materials, tools and techniques used for it- and the research and development done in this field by institutional and industrial laboratories. Most innovations have remained in labs; research and development activities have ended up as academic exercises. The government, along with numerous other semi and non-government organizations has attempted to diffuse research through various means- training centers, vocational institutes, informative and promotional publications, awards, etc. But their effect, or perhaps their reach and influence, seems to be extremely marginal.

With such a background, it becomes important, or in fact, imperative, to investigate this issue of transfer of knowledge, change acceptance and transformation. The profession of construction workers today is in a state of flux. On one side, he is still engaged in handicraft- long, timeless and laborious ways of building; while on the other, he has to cope with the changing times- changing materials, changing markets and thereby changing demands on his profession. But seemingly, he has evolved a way to adopt. A stone chiseler and a crane operator are both realities in today's India.

So, to understand the phenomenon of technology and innovation diffusion in a traditional system, what would be more appropriate than the study of these very people who are the target users[1] of the new knowledge- new materials, tools and techniques- the construction workers- the traditional home builders.

[1] Target users could differ for different technologies. Architects, Engineers, Civil contractors etc. could be the target users in some cases. Refer to this issue in Chapter 6.

How do they operate? Where and how do they train themselves? What are their sources of knowledge? What are their sources of innovations? How and why are innovations accepted and rejected? How does technology and innovation diffuse in their system? These are some of the valid questions that need to be asked and investigated. This study will pursue these questions for an identified sample of these workers and attempt to evolve an overall picture of the mechanisms of operation, development, adoption and evolution from this studied sample. Explanations would be sought to the observed state of affairs in consideration with the social, educational, economic, and professional circumstances of these workers. This would then be used to identify and generalize on the issues and conflicts involved in knowledge transfer from modern to traditional societies and to comment on the process of transformation of societies and cultures in the wake of industrialization.

1.2 Research Question:

What is the general state and process of absorption of building technology and innovations by skilled construction workers in the Pune metropolitan region in India? What are the factors influencing it?

1.3 Hypothesis:

Technological advancement and innovation introduction is closely linked to workers' system of operation, their accessibility to technology and innovations and their social background.

1.4 Rationale:

In developing countries, where housing shortage is a characteristic feature and government and semi government organizations actively provide mass housing, the choice of technology for such schemes is always an issue of debate. Proponents of alternative technologies, local technologies or industrial technologies each justify their point of view. But many a times, results with any of these technologies are far from commendable. Many studies of such labeled technologies have generally found them to be incompatible with the local conditions and lifestyle. This is not only a matter of cultural adaptability as may be popularly thought, but issues of a more practical nature are involved. The repair and maintenance of the structure, additions and modifications required to it, its replicability and the economic and resource feasibility and availability are all realistic issues in addition to intangible aspects like its social image and acceptability that need to be considered before making the choice of technology. With the shift in the policy of providing housing from the provision of built houses to the provision of developed land for owner built housing, the responsibility of the choice of technology has shifted from the providing agency to the user/ home builder. This means, houses would be built with materials and by workers readily available in the market and affordable to the client. Construction workers available in the market thereby become a major and valuable resource along with materials and equipment for construction. This is more so in low-income group settlements and most of the informal housing where professional technical assistance (architects and engineers) is virtually absent and unaffordable and in its place construction workers are responsible for the buildings in a

large way. In such a scenario, the housing built is a product of the workers' expertise. If the physical quality and efficiency of this housing is of any concern, it is important to gauge and upgrade the quality of this resource responsible for its production. How is this resource created? What is its quality and potentials? What is its modus operandi? Such questions become important in this regard.

It is also evident in this scenario that only that technology that is known to the average construction worker is going to be used for building the majority housing stock. This is also true for most of the formal housing too, where known and prevalent technology is preferred to innovations.

It is a common observation that technologies developed in labs never reach the field. A major reason of this gap in the technology transfer is the lack of conversance of the construction workers with such technologies. It has to be realized that any innovation can be only delivered effectively through the system of practicing construction workers. To develop any strategies thereof, it is imperative to first understand the prevalent systems of technology absorption, the factors influencing them and also the very nature and extent of innovations and changes absorbed by this group.

To emulate members of higher social or economic order is a common human tendency. It holds good even for the choice of construction materials and technology used for building houses. To have a special technology for a particular class of people thus amounts to branding that class of a particular social or economic order and is seldom welcome by the members of that class. Given a choice, the use of materials and techniques available in the open market are used, not only due to circumstantial compulsions but also by choice. This is enough to say that alternative technologies cannot be accepted unless they become

a part of the marketplace technologies. In effect, the market technologies are the real mass housing technologies. A prudent attitude therefore would be to enrich these technologies and also their delivering agents- the workers- and ensure the better understanding, quality and efficiency of these technologies despite losses of the same during the diffusion process. For this process too, the understanding of the construction workers, their technology sources, their comprehension of various technologies, their systems of acquiring and using technologies and training for them, the merits/demerits of these systems and the potential of this human resource of the home building industry is essential.

Very little research work has been done on construction workers with respect to technology absorption. Detailed diffusion studies have been done by economists, sociologists, anthropologists and geographers. For various industries, including agriculture[2] such studies have been a source of immense academic and application value. Similar studies for the building industry, especially the housing sector,[3] are hardly found. Whatever studies are done lack the relation between the workers' social background, work methods, employment types, educational background, position in the construction activity and the building industry as a whole on one hand, and their accessibility to technology and innovations along with its absorption and diffusion, its effect on the work and working environment, its appropriateness and viability etc. on the other. Only this

[2] Some studies have been done for technology transfer in large construction projects such as dams, irrigation canals, industries, roads, etc. These though are not enough to assess the situation of the housing sector of the construction industry. Also these studies mostly concentrate on technology transfer to engineers, contractors and other people higher on the hierarchy ladder and very rarely consider construction workers as a subject of study. In addition, the cases are studied in the light of technology transfer from first world to third world countries rather than transfer within the indigenous industry.

[3] It is acknowledged that the housing sector cannot be considered in isolation for such a study and that transfer process often operates across the sectoral boundaries. It is only meant here that this sector, in spite

correlation can fully explain any phenomena at the workers level. How does the transfer system operate, how are the system and the effectiveness of the transfer process related to each other, what factors affect the rate of technology transfer and innovation introduction and acceptance, where does a worker stand in the hierarchy of technology accessibility and absorption are questions that need to be answered. Workers are the actual users of technology and, by number, the largest user group (refer table 5 in appendix). Therefore their role as agents of transfer rather than mere recipients also needs investigation. Their feedback on innovations and a possible contribution towards making some are overlooked. The study of technology transfer and diffusion could be only complete with the study of the transfer and diffusion process that takes place at this level, which in all probability is the level of the last actual user of technology. The proactive role workers do and could play not only in technology and innovation transfer, but also its evolution could be identified.

1.5 Methodology:

The method adopted for the study can be broadly explained as a study of selected samples of construction workers. The sample represents most of the variables found in this category. A thorough study of each sample with respect to the relevant topics mentioned hereto is made. It is supplemented by observations and inferences of other related studies and also by conversations with professionals (architects and engineers) working in the field. Data is classified into various tables and inferences drawn about

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of being the largest component of the total building industry activity and revenue and customer wise, has not been the focus of any such study.

identified aspects of workers' systems. Trade wise observations are also made. Broad inferences are drawn from the overall study at the end.

Data Collection: A large part of the data consists of conversations with workers on relevant topics. Supporting data comes from literature and interviews with practicing architects and structural engineers[4]. The conversations are informal, without any questionnaire. This is necessary since the nature of queries and information sought differs for different trades in the construction process as they do with each individual case of the workers. The following list is a fair generalization of the topics discussed in the course of the conversations:

1. Family background, education, social position, family lifestyle
2. Life in the hometown, construction practices there, changes in these factors over time
3. Family occupation/ occupations of other members of the family
4. Reasons for the choice of this profession, initial training, the learning and practicing process, working conditions, tools, materials and processes then, nature of work then
5. Changes over time in all the above four factors, the process of knowing about and adopting these changes
6. The subsequent changes in other factors like working time, efficiency, payment etc.
7. Acquisition of allied skills like material estimation, quantity checking, bill preparation, use of different units of measurement, understanding of drawings, etc.
8. Routine work, any kind of work done different than the routine job, the experience of doing and learning that job, difficulties in acquiring any skill and learning a new job
9. The process of becoming a mistry

10. The workers working under him, their skills, their training, the passing of information from him to them
11. His contacts with the others in this profession, the nature of interaction with them, his interaction with suppliers of materials, tools etc.
12. His reading of the prevailing market conditions and their effect on his work.

Apart from asking for information, a number of things are judged during the conversation without his knowing. These include:

1. Conceptual understanding of a technology or material
2. Attitude towards the profession
3. Attitude towards change
4. Professional and personal aspirations and the perceived way to fulfill those
5. Attitude towards new technology
6. Creative capacity
7. Willingness and capacity to take risks/ tread new paths
8. Self confidence

Conversations were roughly laid out in the order of the above list. Sometimes, they would follow a different course but covered all the listed topics nevertheless. In order not to make the speaker conscious of what he says, conversations were not taped nor were notes taken while speaking. The entire conversation was written down along with comments and notes later in the day.

Samples: An intensive investigation of less number of samples rather than an extensive survey of a large number was the strategy adopted. A sample size of thirty workers was

[4] The literature reviewed for background studies and recorded in the accompanying literature review provides the guideline for data collection and analysis. Most of this literature is presented in the

finalized after initial sample testing of ten workers. The home building activity was divided into six major trades viz. Concreting, masonry, carpentry, fabrication, flooring and painting, and electrification and plumbing. A sample size of five workers per trade was considered adequate based on the range of possible variables in the sample type (electrification and plumbing are grouped together and a sample of a total of five workers taken for the group; similarly flooring-tiling and painting are represented as a group though workers for all four trades are always different. A sample size of 5 was considered unnecessary for these trades for a limited number of significant variables in the workers characteristics).[5] Each worker in each trade was selected so as to cover the maximum variables in the five samples.

Variables: The regions of origin of workers, their age and years of experience and scope of exposure, their source, period and nature of training, their nature of employment, their skills and particulars of technique used, the nature and scale of work, their work history, their family background and profession, their education and social position are all variables and a good mix of each was sought in the selected samples.

A short set of questions was prepared to assess the characteristic that the sample represented. Repetitive samples were discarded.

Cross check samples: One sample from each trade, other than the five already selected, was chosen as a sample for cross checking observations made and inferences drawn from the collected data. This was to demonstrate the validity of observations and to put to rest any apprehensions about generalizing the observations made from a restricted number of

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accompanying literature review.

[5] Also refer to table 6 in appendix for a comparison between the strength of these workers as compared to workers in the other four trades

samples. Samples for cross checking were randomly selected without a prior screening of their characteristics.

Allied data from architects and engineers: A chosen sample of architects and engineers was interviewed. The topics of discussion during these interviews were experiences of training workers and passing a technology, assessment of the capacity and state of workers, factors affecting innovation adoption by architects and engineers, sources of innovations for them, the academic and the practical sides of the construction field, tendering systems, contracts and role of builders, their role in technology development and dissipation, etc. Architects and engineers were chosen on the basis of their work. Only those who had experimented with alternative technologies or had actively trained workers were considered. An architect representing the majority of conventional architects was also included in the sample.

Classification and Analysis of data: The data collected through conversations with workers is classified under the following heads: Personal and family background, Professional training, Comprehension and allied skills, Work team, Entry into and choice of profession, Employment, Source of innovation, Acquisition and use of innovations, etc. Various sub heads like changes experienced by traditional workers, employment and source of innovation, source of informal training, nature of self-input of workers, etc. classify the data into further details. The basic classification is done separately for each trade. Further classifications are not based on trades but are correlations between various characteristics listed in the basic classification. Tables are used to record the classifications. The classification is numerical. The number of workers prescribing to a

particular sub heading is recorded for each trade. Characteristics not represented in this classification are separately recorded.

Interpretation and Inferences: Inferences from the analyzed data are recorded. By supplementing these with the overall understanding of the field from literature and field experience, interpretations are made.

1.6 Scope and Limitations:

The following factors determine the scope and limitations of the study:

1. Region: The present study is restricted to the metropolitan region of Pune in the state of Maharashtra in western India.[6] Although minor variations would be observed in other regions on account of differences in economy, local markets, kind of work demanded, professionals available etc. on a broader level, the study would still hold good.
2. Number of samples: A restricted number of samples (30) might be inadequate for observations based on statistics but the methodology is thereby evolved to suit intensive study of a few samples rather than an extensive study. The relevance of extensive study is fully appreciated, yet for the restrictions of time, resources and scope, the sample size is restricted and the methodology altered.

[6] A few samples are from towns beyond this area within a range not more than two hundred km. These were included due to some specific projects employing innovative techniques not easily found in the Pune region.

3. Number of trades: Six trades are identified to represent fully the home building activity. Apart from these six, trades such as earthworks, glazing, etc. and specialty skills are also needed for house construction. But the six trades covered constitute the major and the basic trades required for homebuilding.
4. Reliance on oral information as told by workers: A major part of the dissertation is based on conversations with workers. There has been no crosschecking of information given by the workers about themselves and their work. Most of the information is assumed to be true unless suspected. Subjective information is classified separately under 'self report'.
5. Not checked for all innovations: Each trade has a number of aspects that could come under the broad umbrella of 'innovation' as defined hereunder. The present study though does not follow the absorption of all or any specific of such innovations. It concentrates on innovations of a generic category as exemplified hereunder:

   Concreting: ferrocement

   Masonry: any type of new masonry blocks, panel systems or new methods like stonecrete

   Carpentry: any new types of boards, new tools, new hardware

   Fabrication: new tools, new sections

   Flooring: new materials, new techniques of fixing, new tools

   Electrical: new devices, new wiring and conduiting materials, new fixtures

   Plumbing: new piping materials, new fixtures, new storage and waste disposal devices.

6. Limited mostly to residential construction workers: Some other buildings may have worker types that are not typical to residential construction. e.g. a centrally air conditioned office building will have teams of workers working on ducting, cabling etc. which are specialized jobs not found in residential construction. It is a rare occurrence that these workers will find employment in the residential sector of the construction activity. So they are not considered. But it is recognized that the techniques used and learnt in such non-residential projects do have some impact on the residential sector and the workers working for it. This aspect is not studied here due to limitations of time and resources and also the scope of the study.

1.7 Dissertation layout:

The dissertation is presented in seven chapters:

Chapter 1: Introduction: Introduces the topic and its rationale, poses the research question, and states the methodology.

Chapter 2: Literature review (Factors affecting innovation diffusion)

Chapter 3: Building trades in the Pune region: A brief commentary on the state of building technology and construction workers in India and Pune and description of identified building trades and practices in the study region.

Chapter 4: Classified data, observations and inferences: Brief profiles of selected samples and data from the conversations with the workers classified into different categories with a brief explanation of each category and its relevance. Observations from the classified data and inferences made thereof regarding each of the aspect identified for classification.

Chapter 5: Tradewise discussion: Observations and inferences for each of the six trades from the classified data.

Chapter 6: A discussion with field professionals: Views expressed by architects and engineers on various issues relevant to the research

Chapter 7: Diffusion and Workers- Present and Future: Findings on the relationship between technology and innovation diffusion and workers based on the research conducted for the dissertation followed by a conceptual model to overcome some drawbacks of the current situation

Apart from the seven chapters, an abstract in English and French, a table of contents, an appendix, and a bibliography accompany the dissertation.

1.8 Definitions:

1. Technology: Technology includes materials and techniques and tools (product and production technology) used for specific tasks. In the context of this dissertation, the tasks, and thereby the scope of the term technology, is restricted to building technology and associated trades. It also implies technical know-how and immaterial aspects like concepts and organization[7].
2. Innovation: Any new material, technique or tool is included under 'innovation'. Innovation does not necessarily have to be a completely new invention but may be a modification or an improvisation on the existing material, tool or technique. (Refer 1.6 for examples)

[7] Also refer to Drewer's description of technology in the context of construction: Drewer, Stephan. "Technology for Development". Mimar: Architecture in Development. No. 38, March 1991.

3. Transfer: Transfer is understood as a state when a worker understands the properties and applications of a technology and can use it without assistance (except in case of technologies that have professional guidance as an integral requirement e.g. structural design)
4. Worker: For the purpose of this dissertation, only skilled workers (also referred to as 'mistry') are considered under 'workers'. There is no age or experience limit but it is essential for the worker to be currently working in the trade. Due to the nature of the building industry in this part of India (and generally all over the country), there are no women in this category. Hence, worker refers to a male worker by default.
5. Trade: A building profession involving practical construction skill is referred to as trade. Six trades are identified for the dissertation, viz. concreting, masonry, carpentry, fabrication, flooring and painting (finishing items), electrification and plumbing (services).
6. Traditional technology: Technology that has evolved over the years from the family traditions of Indian construction professionals (skilled workers- craftsmen) is referred to as traditional technology.

Chapter 2 : Literature Review : Factors affecting innovation diffusion

The issue of diffusion of innovations has been of interest to researchers in many fields. This study is carried out for different purposes and serves different goals. It could be undertaken to understand development of production systems in industry or agriculture, to design promotion methods for innovations, to look at the interrelationship of technology and human resources, to gauge the economic growth of a nation, to study the influence of political and social factors on development or to understand culture and tradition and change. For architects, it could provide insights into the process of acceptance of innovations in general, and building innovations in particular and give a broad idea of the multitude of factors involved in such a process and thereby caution them against working in isolation from the ground realities of the field. A large body of literature is available on the subject of diffusion of innovations. It is in the form of research reports, case studies, literature reviews, proposed models, new theories etc. A large portion of this research is done by geographers, sociologists and economists, although this type of research was first initiated by anthropologists; economists have been more interested in the impact of technological innovations on growth and development, confining diffusion studies to a particular industry (Cohen, 9). Very little research is done by professionals in and about the construction industry, although a few case studies in other researches are about building innovations. It could therefore be safely said that an understanding of this very important phenomenon of the process of growth and development in the building industry is lacking in building professionals, and that there is no "architectural perspective" on the subject.

India and the world

Pune region (black) in the state of Maharashtra in India

The following chapter is a review of the broad literature on the subject of innovation diffusion. An attempt has been made to represent views on the topic from significant and relevant fields. Whenever possible, examples related to the building industry are favored, but at the same time cases are drawn from fields as diverse as agriculture and computers.

2.1 Definitions

Innovation:

Rogers and Shoemaker define innovation as "an idea , practice, or object perceived as new by an individual. It matters little, so far as human behavior is concerned, whether or not an idea is objectively new as measured by the lapse of time since its first use or discovery. It is the perceived or subjective newness of the idea for the individual that determines his reaction to it. If the idea seems new to an individual, it is an innovation (Rogers and Shoemaker, 19).The above definition is applicable to what is commonly termed as a consumer innovation. Malecki defines firm or technological innovations as " new production inputs, machines, processes, and techniques adopted by firms or entrepreneurs for their own use" (Malecki, 1). Nelson defines innovations as the process by which new products and techniques are introduced into the economic system. Successful innovation results in the capability of doing something that could not be done before, or at least not so well, or so economically (Nelson, 339).

Diffusion:

Scholars in different fields have defined diffusion in different ways. For anthropologists, "Diffusion is the process, usually but not necessarily gradual, by which elements or

Scholars in different fields have defined diffusion in different ways. For anthropologists, "Diffusion is the process, usually but not necessarily gradual, by which elements or systems of culture are spread; by which an invention or a new institution adopted in one place is adopted in neighboring areas and in some cases, continues to be adopted in adjacent ones until it may spread over the whole earth" (Kroeber, 139). Sociologists view "Cultural diffusion (as) the concept widely found in sociological literature to symbolize the process by which inventions become adopted by society" (Bowers, 826). More specifically, for them, " ... the process of diffusion may be characterized as the acceptance over time of some specific item-- an idea or practice, by individuals, groups or other adopting units, linked to specific channels of communication, to a social structure, and to a given system of values, or culture" (Katz, 240). Today, this could be considered, in sociology, as a classical definition of diffusion. Within the social sciences, each discipline tends to emphasize certain elements involved in the diffusion process. The meaning of process in this context is the way in which the diffusion of a phenomenon proceeds from one adopting unit to another. Implicit in such definition of process is the emphasis on explanation of the cause that influence the acceptance of a phenomenon (Cohen,5-6). Geographers have looked at spatial and chronological aspects of diffusion. But they fail to acknowledge the fact that space and time are elements that are external to the diffusion process while social, economic, cultural, psychological or other behavioral factors are the endogenous causes of acceptance, rejection and spread of innovations (Cohen, 13).

Generalizing the above definitions, the process by which an innovation spreads within a social system is called "diffusion". An innovation, however, diffuses within a social

system through its "adoption" by individuals and groups. Diffusion and adoption are thus closely interrelated even though they are conceptually distinct. (Dasgupta, 21)

Adoption:

Adoption too has a variety of definitions and differences generally occur regarding when is adoption said to have taken place. Adoption could be defined by a date, degree or magnitude as its measure. Generally, it could be said that "The growth in popularity of a new idea within the society of its origin (then) comes under the heading of "adoption" , "acceptance", or some similar term, whereas the passage of an idea across ethnic boundaries is usually refereed to as its "spreading", "borrowing", or "diffusion" (Barnett, 291).

2.2 Factors affecting diffusion

Diffusion is affected by a number of diverse factors. Studies have concentrated on one or more of these factors and gauged their effect on the process of diffusion. All have acknowledged the presence of numerous factors affecting diffusion other than those considered in that particular study. Diffusion could thus be understood in a broad sense but never could be predicted or represented by a formula. But time and again, studies have led to, and therefore agreed on some recurring factors which play a significant role in the diffusion process. Broadly, these could be grouped as social, economic, political and cultural factors as well as characteristics of the industry and adoption unit and the characteristics of the innovation itself. A brief review of each is presented here under.

Social:

According to Nelkin, a stable and well-established system may be particularly resistant to social change (Nelkin, 97). Adoption and diffusion patterns differ in different societies. Patterns differ for different innovations even within the same society. Many aspects of a social system are studied to understand their effects on diffusion. Among these, structural characteristics and systems of beliefs and values are the two main types. Structural characteristics comprise of caste structure, leadership structure, structure of activities and attitudinal structure. Dasgupta also mentions "reference groups" as an influential factor in a social structure. A reference group is a group to which an individual relates himself as a part or to which he aspires to relate himself psychologically. e.g.: kin groups, friendship groups, work-exchange groups etc. Reference groups, depending on the importance the individual adopter attaches to them may have great influence on his thinking and behavior. A study in a village found that a farmer's adoption of recommended farm practices was influenced by the adoption rate of his friends, relatives, and work-exchange groups (Dasgupta, 95).

Various models to explain innovation diffusion in a social structure are proposed. Dasgupta cites one such model in the context of diffusion of agricultural innovations in India. According to this model, first few members in a social system are so innovative that they adopt the innovation almost immediately after they come to know about it. These early adopters influence the other members of a community to adopt the innovation as they interact with them. After the innovation is adopted by a few farmers, they influence a few others, who, in turn, offer new stimulus to the remaining ones. (Dasgupta, 21). This is termed as "interaction effect".

Rothman has further identified "opinion leaders" among any society and hypothised that the likelihood that an innovation will be adopted by a larger population is increased if it is first utilized by smaller group of opinion leaders. He cites an example of Carlson's study[8] of how the new math became part of the curriculum of schools in Allegheny County, Pennsylvania[9] (Rothman, 24-25). Opinion leaders are often characterized by higher social status, more education, greater media exposure, more contact with change agent, and more openness to innovative ideas. (Rothman, 26). Other than playing the role of strong influences in the diffusion of innovations, Rogers states that by way of higher -status, more cosmopolitan opinion leaders, new ideas enter a system ; the more cosmopolitan the opinion leaders are, the greater is their influence. The role of opinion leaders in the rejection of an innovation is also exemplified in case of construction industry by Nelkin. Opinion leaders oppose an innovation when their interests are jeopardized. "When a new and less costly building technique would disrupt the construction industry, one can rely on the opposition of those building interests that would be disadvantaged, (but not on the advocacy of those who might benefit from cheaper housing)". In the presence of powerful spokesmen for old technologies and the absence of effective ones for the new, promotion of relative merits of alternative technologies is rendered difficult if not impossible"(Nelkin, 99-100).

Influence of social aspects gradually acquire political undertones. Political decisions, and interests, go a long way in influencing acceptance or rejection of innovations. As Nelkin

[8] Carlson, Richard O. "School Superintendents and Adoption of Modern Math: A Social Structure Profile", in Matthew B. Miles, ed., Innovation in Education. New York: Teachers College, Columbia University, 1964.

[9] Five superintendents closely associated with one another introduced the new approach in 1959. As a result of their example and contacts with other superintendents, an additional 10 schools adopted it in 1960. Then 12 more schools tried it in 1961. By the end of 1963, 38 schools were employing this altogether different method of teaching mathematics.

forces which shape it, but more about the way community decisions are made" (Nelkin, 74).

Political:

The effect and strength of political factors is best illustrated in the case of the CIPT (Civilian Industrial Technology Program) proposed to the US federal government in 1962 and subsequently scrapped in 1963. CIPT was proposed on the basis that the construction industry's problems were becoming acute, the gap between technological potential and actual building practice was widening and a growing market was bringing greater challenge and opportunity. At the same time, building industry was fragmented, there was no single agency responsible for building science and technology, and research was limited by available funds and personnel. So the CIPT proposed to encourage and support building science and technology centers, evaluate new building materials, components and concepts, study probable course of future technological progress, and improve dissemination of information on building science and technology.[10]

This program however was seen as a threat to private enterprise and the advantageous prevalent state of affairs by many, and hence naturally came under severe criticism. Arguments ranged from the assessment of the construction industry as "lagging" being wrong (Nelkin, 56) and ill founded to the program potentially upsetting the "delicate free enterprise mechanisms (Nelkin, 43) and interfering with the competitive balance in industry (Nelkin, 61). Nelkin profiles the position many organizations and professional

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[10] Subcommittee on Deficiencies of the Committee on Appropriations, House of Representatives, 87th Congress, Second Session, Hearings on Supplemental Appropriations Bill, August 1962, p. 48-49.

associations took on the issue and how they found themselves in contradictory positions[11]. The strong opposition from Congressmen is hinted to be rooted in the mutual vested interests of politicians and businessman.[12] Private engineering firms did not want government competition (Nelkin, 67). All these factors converged politically to reject the CIPT which was seen as a "critical social need" by its supporters.[13]

The relationship between technology, politics and social problems is thus subtle and complex. Wallace Sayre and Bruce Smith have described a "spectrum of readiness", examining social problems according to the degree to which they are both politically and technologically ready for solution (Nelkin, 74).[14]

Cultural:

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[11] Associations like the BRAB and AIA were in an awkward position. Their clients- the builders- were opposed to the program while the associations were supposed to be the progressive force in industry. A number of engineering associations refused to take a position- they were sensitive to the relationships of their members to industry, and tended to take politically safe positions which protected these relationships (Nelkin, 65).

[12] The state of Ohio (Congressman Bow's constituency- he was a very strong, vocal and influential opponent of the CIPT) ranked first in the nation in the no. of employees in the stone, clay and glass products industries- especially ceramic wall and floor tiles. These industries, concerned about public control of technological innovations in materials development, took an active part against CITP. They were threatened by the possible development of competitive materials as a result of a Govt. R and D program. Since the installation of bricks and tiles is labor intensive, innovating material requiring less labor would pose a significant threat. (Nelkin, 55)

[13] Glenn Beyer, director of the Center of Housing and Environmental Studies at Cornell University and Gordon Fisher, associate dean of engineering at Cornell University supported the program on factual and sound arguments, but in vain. (See Arguments for and against the CIPT, Nelkin, 71)

[14] Political influence is cited as one of the factors of the failure of India's program for village education through satellite TV. The greater political clout of urban India directed the technology to be used for entertainment programs rather than developmental communication which was its original objective (See Bhalla, 194-208 and 244).

Cultural values and their effect on acceptance or rejection of innovations is studied with respect to agricultural innovations. Dasgupta cites two sets of values- traditional and modern. Familism, fatalism, passivism, sacred orientation, conservatism, and orientation to the past are considered traditional values while scientism, risk orientation, business or profit orientation, rationality, secular orientation, political consciousness, achievement motivation, deferred gratification are considered modern values (Dasgupta, 88, 91). It is also observed that modern values are on the rise as the boundaries of value systems between rural (considered traditional) and urban (considered modern) societies are blurred in the present times.

Economic:

Economic profitability of an innovation plays a major role in adoptio of innovations. According to Linstone and Sahal, the more profitable the innovation, the greater the rate of diffusion (Linstone and Sahal, 59). Dasgupta notes that risk, complexity and lack of compatibility rather than cost are the main reasons for the rejection of inovations by the non-adopters. Economic profitability of the innovations do not necessarily stimulate their adoption (Dasgupta, 40). But for technological innovations, in most cases, it is economic considerations by the adopting units that determine when to adopt and the rate of adoption. Firms will not adopt any innovation unless the expected returns on their investment (monetory and human and social resources) are going to be atleast equal to those that are available, if the resources would be invested in conventional or alternative use. He further cites Edwin Mansfield[15] who demonstrated that the rate of adoption

[15] Mansfield, Edwin. "Technical Change and the Rate of Immitation". Econometrica, XXIX (1961), 741-66.

among industrial firms depends mainly on the profitability of accepting an innovation and the size of the investment required (Cohen, 21- 23). (Also see 'Relative advantage' on the following pages).

Communication:

According to Trade, dissemination of information is clearly the basic cause of diffusion. Information could be disseminated through various means and the sources from which target populations receive information are varied too. Dasgupta classifies information sources into institutional or formal and non-institutional or informal. They could also be classified as personal and impersonal ; impersonal covering the print and the non-print mass media. Sources could be classified according to their location with respect to their users as cosmopolite and localite. Dasgupta mentions that early adopters and opinion leaders are the main users of cosmopolite sources while the late adopters usually get informed by localite sources.

But spread of information alone does not ensure adoption. Credibility of the sources to the users is an important factor in the process. Credibility is defined as the degree to which (users) trust particular sources of information to be accurate and useful for their purpose[16]. Who uses what sources of information depends on individual profiles but is certainly influenced by education and access. Cohen states that both mass media and

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[16] A method to measure farmers perception of source credibility is to ask to list/ paired comparison/ ask about source of information. they used for the innovations adopted- the credibility is determined by the frequency with which they are used.(Dasgupta, 113-114)

interpersonal relationships affect diffusion, especially when individuals are adoption units but when the adoption unit is large enough, very little is known about the role of information and communication media and of personal interaction in affecting the decision to adopt an innovation.

In case of technological innovations, where information is highly technical and essential to a firms appraisal of costs and relative advantages of the innovation, adoption of technological innovations lags years behind the initial receipt of information because of the need for information of a highly specialized nature. Also, cost and technical personnel are important factors for adoption of technological innovations, so firms may not have resources even if they willing to adopt (Brown, 157).

Adoption processes and factors influencing them differ when the adoption unit is an individual or a firm.[17] They also differ when an innovation is a consumer or technological one. Though social, political, economic and communication factors affect both categories of adoption units and innovations, some factors are unique to each type. Characteristics of the adopting firms, industry and the innovation itself profoundly affect the rate and pattern of adoption of technological innovations by firms.[18]

Diffusion agency:

Brown argues that the traditional belief that adopters have an equal opportunity to adopt could be challenged and it could be argued that in many cases it is egregiously and purposely unequal. Accordingly, adoption takes place within a constraint set established

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[17] The adoption unit is defined by the item that is undergoing diffusion.(Cohen, 14)

[18] Characteristics of the innovation also play an important role in consumer innovations, but the characteristics considered for these innovations may differ from those of technological innovations.

by government and private institutions. Unless some government, entrepreneurial or non-profit organization makes the innovation available at or near the location of the potential adopter, the adoption units will not have the option to adopt in the first place. Once this is in place, promotional communication strategy of the agency and the resulting awareness in the adopters will be the consideration. Also, access of the adopter will depend on the cost of innovation, the ability of the adopter to raise capital and the sources available to him to do so. Further, the adopter's proximity to infrastructure relevant to using the innovation will play a role in his ability to adopt. Thus, adoption will be affected by the ways in which relevant resources are made available or allocated to the adopter, both by propagators of the innovations and the society at large, as well as the adopter's ability to utilize these resources, which itself may be a societal product. This approach to innovation diffusion shifts the focus to the diffusion agency rather than the adopter (Brown, 8,9).

Characteristics of the firm:

Brown has mentioned three major characteristics of firms that affect adoption. Firm size is believed to be the most prominent characteristic having a bearing on adoption of an innovation as well as on many other characteristics. Large firms have advantages over smaller firms in adoption of technological innovations because they have greater ability to raise capital, to bear cost of the innovation and bear to take the risk of failure. They can also better afford the managerial and technical specialists often needed to evaluate the innovation and implement it. One might thereby infer that adoption takes place first by larger firms and is consequently followed by smaller ones. But though size sequence of

adoption of innovations holds true for high cost innovations , it might not be true for low cost innovations. (Meyers and Marquis)[19]. This suggests that firm size might operate more as a threshold than as a scale for adoption. The threshold size of firms may vary for different technologies.(Brown, 156).

The second characteristic is the aggressiveness and innovativeness of a firm's management. Brown refers to Malecki and Waite20 observing that, medium size firms are more aggressive and innovative as they have more incentive to grow and improve their competitive position. Time taken by a firm to make a decision regarding adoption/ rejection also depends on the kind of management. The more alert the management about the innovation, the shorter the time taken (Nabseth, 7).

Level of information in the firm about the innovation is the third characteristic. As the CITP proposal observed, medium and small firms generally cannot employ technical staff to review, evaluate and apply the technical information effectively (Nelkin, 108) and this hampers the adoption process.

Other than these three characteristics, competition among firms initiates adoption. Early adoption takes place because some firms wish to gain advantage over their competitors. Intra industry competition is one of the causes of the bandwagon effects associated with the sharply rising middle portion of the S curve of diffusion (Brown, 155).

Adoption of innovations in different industries follow different patterns and processes. The nature of the industry determines the type of innovations made for it as well as

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[19] Nabseth and Ray cite examples from their study of smaller firms taking lead in the introduction of a new process (see Nabseth and Ray, 308).

[20] Malecki, 1975, 1977; Waite, 1973. Brown illustrates this point with the advertisements for Avis automobile rental company which proclaim 'We try harder' because of their number two position behind Hertz in the car rental business.

attitudes and factors concerning adoption. Building industry is unique for a number of reasons. Its characteristics are therefore solely reviewed here under.

Characteristics of the industry:

As Nelkin has rightly observed that in housing industry, technology is largely based on practical experience rather than on research. The character of technology in the building industry emphasizing craft methods rather than science based techniques operates against innovation. Industrialized techniques are not only commercially disruptive but they threaten the assumption that building methods are developed through a long history of empirical experience. An important obstacle to change is that inefficiency and costly design are rewarding to the many diverse segments of the industry. There is little incentive for technological competence which might lead to cost reduction; indeed there is a certain stake in maintaining inefficiencies, particularly in the view of the industry's highly competitive character. The introduction of new technology would upset the highly competitive balance (Nelkin, 97). No single group is responsible for building science nor is there an interdisciplinary, industry wide, scientific tradition, scientific literature, or professional corps. (Nelkin, 106)[21]. With this background it is interesting to read a statement by Whitlock[22] stating that a building research program already existed in the

[21] According to Nelkin the attitude of any industry to technological innovation could be gauged from the amounts it spends or scientists and research engineers it employs. He quotes figures from Beyer (Beyer, Glenn, H. Housing and Society. New York: Macmillan, 1965.) about funds actually spent by each industry on R and D in 1956 as: construction $ 24,100,000, chemical $ 517,700,000, electrical equipment $ 461,000,000, machinery $ 390,300,000, aircraft $ 269,900,000 and from National Science Foundation (National Science Foundation. Scientific and Technical Personnel in History, 1960. Report 61-75, Washington, D.C.: GPO, 1961.) about the number of scientists and research engineers employed by various industries in 1960 as: construction: 2000, chemical: 36000, electrical equipment 62600, machinery 28200, aircraft 64000. (Nelkin, 8,9)

[22] Douglas Whitlock was the founder of Structural Clay Products Institute, a $260 million industry, eleven of whose member companies and contributing associates were from Ohio. He was a personal friend of

industry, but it was somewhat hidden owing to competitive relationships that led to secrecy on matters of innovations. (Nelkin, 62).

Characteristics of the innovation:

In addition to all the factors mentioned hereto that affect adoption of innovations, the innovation itself is responsible for its acceptance or rejection. Studies have shown that while certain innovations are quick in their spread, certain ones take a long time; others die out- not necessarily due to the factors external to the innovations, but due to the very characteristics of the innovations themselves. As a result, it is difficult to formulate a typical model for the diffusion of all innovations. Innovations of a similar type too show varied degrees of diffusion on account of differences in some of their individual characteristics. Dasgupta, while reviewing literature on the diffusion of agricultural innovations, has identified some inherent characteristics of innovations that affect its diffusion. But he mentions earlier that diffusion rates of innovations are affected not so much by their real characteristics as by the way they are perceived by (users) who are their potential adopters (Dasgupta, 28).

Utility (importance of the need fulfilled by the innovation), communicability (ease with which the usefulness of the practice can be communicated), immediacy of results, complexity of innovation, cost involved in use, and the ideation involved in use (whether or not it is possible for the potential adopter to understand and visualize the extent to which each component of the innovation contributes to the desired result) are major

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Frank Bow, having worked with him in Republican politics. He was also an officer in the Building Products Institute and the Producers' Council. He had tried to keep out federal government of R and D activities through a long time series of behind-the-scene activities. With much backing from the

factors affecting adoption of any innovation. These are more or less similar to the ones identified by Rogers and Shoemaker:

Relative Advantage:

Relative advantage can be explained as the importance of the need fulfilled by the innovtion. It could be measured by the economic profitability of the innovation, though the advantage may not be always perceived in economic terms by the adopters (see Dasgupta, 32-33). Also, there are a number of problems in judging relative advantage in terms of economic profitability. Firstly, since old and new technologies are never the exact equivalents of one another, it is difficult to compare unit prices directly. Cost effectiveness implies minimum cost per unit of utility - which again is difficult to measure (see Stern, Ayres and Shapanka, 123, 124). Secondly, profitability changes for a new process over time and for a given firm. This is because innovations improve over time and factor unit prices change- often in favor of the innovation[23,24].

Compatibility:

Compatibility is perceived in terms of its consistency with existing values and practices. A distinction could be made between physical compatibility (degree which an innovation is consistent with existing practices relating to economic activities) and cultural

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construction industry, and his successful articulation of traditional concerns of the industry about government intervention, he proved a very influential opponent of the CITP (Nelkin, 55,60).

[23] Brown argues that innovation is a continuous process, in contrast to the assumption implicit in most diffusion research that the innovation is a set, non-changing phenomenon (Brown, 154). It shold be also noted that slowness in adoption is encouraged by continuity of the innovation process so that leaders in introducing the process may be followers in its profitability (Nabseth and Ray, 303).

[24] Examples of this would be newer computers which are far more improvised than their predecessors yet much cheaper.

compatibility (degree to which an innovation is consistent with existing values, beliefs, habits, and tradition in a social system).

Complexity:

It refers to the complexity involved in the perception and implementation of an innovation. An innovation which is relatively simple to understand and use diffuses quickly.

Trialibility:

It is also referred to as divisibility. It is the degree to which an innovation can be tried out by a user on a limited scale before deciding to adopt it. In most cases, especially for medium size and/or capacity adopters, trialibility of an innovation is important because the feeling of insecurity in trying something new is minimized. Trial gives an opportunity to evaluate the innovation in terms of feasibility and applicability to the user's situation. Hence it is observed that more triable innovations diffuse faster[25]. Demonstration projects, pilot programs, modeling of new roles of behavior, free samples are all analogs to trialibility (Rothman, 25).

Observability:

It is the degree to which the results of an innovation are observable, demonstrable and communicable to the users. It is similar to demonstrability and communicability.

Apart from the characteristics mentioned above, there are other aspects of an innovation that influence its diffusion. The nature of the innovation- whether it is an addition to[26], or

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[25] Also see Rothman, p. 23

[26] Referring to blending of traditional and new technologies, Bhalla emphasizes the importance of the knowledge of the nature and characteristics of traditional activities/ technologies with which new technologies are to be integrated. The use of new technologies should improve the efficiency of these practices without radically altering the associated skill and input requirements for a proper fusion into the traditional economic and socio- cultural practices. (Bhalla, 246)

an improvement of, or a replacement of an existing technology / product, its implications on the existing practices and systems[27], the cost of introducing and using the innovation etc. all affect the diffusion process[28]. As per the conventional investment theory, the rate of diffusion ought to be greater for additions and slower for replacements. In case of the latter the industry already has a sunk cost to be amortized or written off. Old facilities are more readily displaced than newer ones. Thus, the innovation constituting a displacement of functioning facilities, and particularly of less old functioning facilities, would have to be more profitable than the innovation constituting an addition to functioning facilities (Brown, 155).

Other Factors:

Many other unclassified factors affect the diffusion process too. Dasgupta suggests a significant association between the level of adoption of a village and its access to extension agencies, urban centers, mass media; population size and literacy; non-human resources such as availability of electricity, equipment and transportation; and organizational, leadership and caste structures (Dasgupta, 98).

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[27] The state of Ohio ranked first in the nation in the number of employees in the stone, clay and glass products industries- especially ceramic wall and floor tiles. These industries, concerned about public control of technological innovations in materials development, took an active part against CITP. They were threatened by the possible development of competitive materials as a result of a government R and D program. Since the installation of bricks and tiles is labor intensive, innovating material requiring less labor would have posed a significant threat. (1-55)

[28] Robertson classifies innovations as: continuous innovations like fluoride toothpaste, menthol cigarettes or annual new model automobile changeovers which are merely alterations of a product and have the least disrupting influence on established consumption patterns; dynamically continuous innovations involving creation of a new product or alteration of an existing one if not involving new consumption patterns- these have more disrupting effects than continuous innovations- electric toothbrushes, electric hair curlers and the Mustang automobile would be the examples; discontinuous innovations involving the establishment of new consumption patterns and the creation of previously unknown products- examples would be television, computers and the automobile (Robertson, 7)

Neighborhood effect and hierarchical effect have been mentioned by Cohen to be responsible for diffusion of an innovation (Planned Regional Shopping Centers- PRSCs- in this case). He explains these effects as follows:

Neighborhood Effect:

Other things being equal, the closer a potential adoption unit to the source of innovation, or to another unit that had already adopted the innovation, the greater the probability that it will adopt before potential adopters that are further away (Cohen, 14).

Hierarchical Effect:

If one defines a base for a hierarchy, be it size, social status, or any other criterion, the higher the ranking of a potential adoption unit in that hierarchy, the greater the chance of adoption before units that are lower on the hierarchy (Cohen, 15).

He further shows in his study on the spread of PRSCs in the US that it indeed followed the hierarchy of size of cities.

Brown mentions institutional effects. According to him, societal concerns give added importance to some innovations that otherwise might have sat on shelf and reduce the importance of other innovations thereby influencing not only the diffusion but also the choice of innovation to be diffused[29] (Brown, 155).

2.3 Diffusion and the building industry:

[29] e.g.pollution control innovations are preferred over innovations involving high levels of pollutant emission.

Although, prima facie, buildings, or more specifically, houses built today look different than those built thirty years ago, the effect of innovation has been minor. A closer look will reveal that what has really changed are accomplishments of materials suppliers and equipment suppliers (e.g.: gypsum wall boards, synthetic wood fiber boards, improvements in quality and durability of finishing material, and improvements in heating systems, plumbing supplies, kitchen equipment and lighting). In so far as the accomplishments of the people who design and build homes (structure and the adjustment of the structure to suit the needs of the occupants), there has been very less innovation (Rassweiler, 44). Some aspects unique to adoption and diffusion of innovations in the building industry are discussed here under:

Rassweiler argues that the building industry has never employed scientists for research nor has it invested in experimentation. It has been no match for other industries which have made at par and integrated research and development activities with production, sales and finance (Rassweiler, 45,46). Technical obstacles: no past knowledge base; no scientific literature publication for dissemination of new knowledge; no trained scientists. Commercial obstacles: fragmented nature poses difficulties for funds required for experimentation, incentive creation to improve building as profit makers are far removed from the building itself, divided responsibility of or the characteristics of the finished building and how it will be constructed, high costs of getting innovations accepted and used in the field. Large percentage of profits go to organizations that are deliberately temporary in nature - as a result, there are no long term investors for even a period of 5 to 10 years which is the time generally required for any innovation to develop and yield profit. Size and sophistication of building companies is far too small than that required.

To initiate and get value of the innovations. The product (house) is such that it cannot be factory made and shipped over a large geographic area; also regional needs and specifications differ and building locally with local techniques and materials is cheaper.

2.4 Diffusion studies:

Numerous studies on the diffusion of innovations in various fields have evolved into scientific and empirical methods of data collection, analysis and interpretation of the subject. A theory of diffusion has been evolving with contributions from numerous researchers and field workers. If not as a complete theory, diffusion is understood with the help of its characteristics and patterns on a much larger generalized scale.

Attempts to plot the cumulative proportions of adopters of an innovation over time within a social system have shown that the resulting curve assumes the form of an S shaped growth curve. This is called the diffusion curve.[30]

The curve starts with a gradual rise denoting the adoption by innovators in a system. It further rises but slightly, when early adopters adopt the innovation through interaction with innovators and by observing the results of its use by the innovators. Gradually, over a period of time the late adopters, who are a large majority in the system, adopt the innovation. This is the period which is reflected in the upward slope of the S shaped diffusion curve. After the majority of the farmers of the social system have adopted the innovation, only a few hard core resisters are left who have not yet adopted the practice. At this stage the second point of inflection of the diffusion curve is reached, and the

[30] See Dasgupta, p.21

upward slope comes to an end. The remaining part of the curve now has a more gentle slope until all intended users adopt the innovation.

Diffusion rates are often measured in terms of proportion of firms using the new technology as compared to those using the old (Brown, 153). Diffusion studies carried out in different fields and with different foci have led to different findings. Broadly, these findings could be classified into two categories (Cohen, 14): findings that are descriptive of how an innovation spreads and findings that are explanatory and that identify and explain the role of factors that affect the course of diffusion[31]. It should be noted here that research on the diffusion of technological innovations has tended to give more attention to the characteristics of the innovation itself and of that of the adopting firm, whereas the consumer innovation tradition has emphasized communications or information flow process (Brown, 153).

But any kind of diffusion study is an intricate and difficult yet interesting undertaking since the spread of a phenomenon is often selective. Many factors are involved in its explanation and it is beyond anybody to account for all. But once certain factors are identified or are hypothesized to influence the course of diffusion, it is important to examine their effect on the spread. Only in such a way can a meaningful body of theory on diffusion be built and be related to the theories of change (Cohen, 5).

The significance of any kind of diffusion studies, be it diffusion of technology, consumer products, behavioral and operational practices, etc. is best summarized by Cohen. "Diffusion studies, especially concerned with the spread of innovations, are assumed to be necessary for understanding a major phenomenon in human life, namely change.....

[31] Neighbor hood effect, hierarchical effect, logistic curve would be examples of descriptive findings while behavior of firms, relative advantage, trialibility, etc. would be examples of explanatory findings.

We speak today about technological change, social, economical, and political changes as well as changes that occur in the environment. In this study, change is assumed to be the phenomenon of acceptance of new modes of behavior or new ways of doing things. Thus, society can be said to have experienced change if its technology, institutions, customs or, in general, its ways of life are different at one point of time than at the other.....It is the author's belief that change always implies a process of diffusion of a new phenomenon, be it material or non material. Thus, learning the ways by which a phenomenon spreads, or fails to do so, can contribute to a better understanding of the process of change". (Cohen, 4,5)

2.5 Models of Diffusion:

Based on the case studies and theories of innovation diffusion, some models of diffusion processes have been proposed. Dasgupta cites a four stage diffusion process. As per this process, explained for agricultural innovations, first a few innovative farmers try out and adopt the innovation after its introduction. These farmers are called innovators. They are characteristically prosperous and venturesome enough to be able to take the risk of trying out an innovative idea or practice. Following this, a larger group, but still a small minority in the village, is influenced by the innovators to adopt the recommended practice. These people termed as early adopters are not too different from the average farmers of a village although they are often respected for their farming ability and successful and discreet ideas and practices. Because of their respectability, they serve as role models for other farmers who seek opinion and advice on farming matters from them. Consequently, a large majority of farmers are influenced by early adopters to adopt

innovation. These are termed as late adopters. Finally, the diffusion process slows down, and the proportionately few remaining farmers gradually adopt the innovation. These laggards are a small group taking the longest time to adopt (Dasgupta, 22-26).

Adoption or rejection of an innovation can also be explained at the level of an individual adopter. At this level, adoption process is a decision making process involving a period of time during in which an individual goes through a number of mental stages before making a final decision to adopt an innovation. The widely accepted sequence of stages in this process is: awareness of the existence of an innovation, interest, evaluation trial, and complete adoption[32] (Dasgupta, 43-45). But it is not necessary for all adopters to go through all the five stages. Especially, late adopters may skip some stages learning from the experrience of earlier adopters. But it is observed that generally, most adopters go through all the stages of the process (refer accompanying figure).

Nabseth and Ray outline the process of adoption for a firm (refer accompanying figure). The first stage of this process is the entry of the first information about a technique. Then, more amd more facts come in from various sources- suppliers, competitors, trade and research associations, or indeed the companies own research and development work. Soon, the awareness stage is reached. Subsequently, plentiful information leads to systematic evaluation. A study to assess the value of the new technique with regard to the firms circumstances is carried out. This is the consideration stage. If the decision is to install the technique, adoption takes place. Adoptions at micro-level add up to diffusion at macro-level (Nabseth and Ray, 6).

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[32] Cited from: North Central Subcommittee for the Study of Diffusion of farm Practices. How Farm People Accept New Ideas. Ames: Iowa Agricultural Extension Service, 1955.

Based on the research on innovation diffusion, attempts have been made to formulate promotion strategies for new products and technologies.

2.6 Afterword:

Models proposed and factors identified are mostly based on empirical studies. It has been acknowledged by many researchers and scholars on the subject that these differ for different cases. A wide background is created by the available literature to base new studies on and each new study in turn adds to this knowledge base with its particular observations and interpretations.

Building industry has been under utilized as a sector for diffusion studies for various reasons, but it does not imply its insignificance. Diffusion studies in the building industry are not only valuable for sociologists, economists or management scholars, but would serve as a valuable database for the industry itself. Product manufacturers and suppliers, building technology research institutes, and architects and planners would not only be more aware of their prescriptions but would also have an aid to make strategies to promote them. The crucial issue of lab-to-land for any new product or technology would be one step ahead in finding an effective mode to achieve its goal.

The literature review gives an idea of the intricacy and multifacatedness of the phenomenon of diffusion. For the purpose of this thesis, it will help to identify specific study areas regarding diffusion of building technology and innovations and to formulate methodologies for data collection, organization analysis and interpretation.

Chapter 3: Building Trades in the Pune Region

3.1 State of Building Technology in India:

If modern building technology is defined as "the practical use of resources for the development of tools that permit specialization of labor, mechanization of production processes and transportation systems, discovery of new forms of energy, standardization of parts, components, or sub assemblies, mass production of goods and services, and automated control systems (Shah 21)", the current technology employed in the building industry in India, at least in most parts, is backward. Scarce capital, ample labor, continued use of traditional technology, small enterprises, temporariness of work and contractual relationships characterize building industry here. Due to the seasonal pattern of work, variations in local geographical conditions and regulatory guidelines of governing bodies, unique needs of projects, constraints on financial resources, and lack of indigenous R and D for this field, the building industry has not been able to modernize much as compared to the other industries. Abundance of manpower vis-à-vis scarcity of finance has encouraged and supported the development of a labor-intensive technology (refer to tables 4, 5, and 6 in the appendix). Vaid also cites the social linkages of technology as a reason for the constrained growth of building technology. Low order of technology draws lower or no skills, pays low wages and draws mostly the underprivileged. Studies show that most construction workers come from the lower castes, which are educationally and economically deprived (see NICMAR and table in annexure). Housing needs and the means to get them fulfilled are varied for different clients based on economic and sometimes social class. Accordingly, it is not possible to

achieve economies of scale for a limited number of homebuilders. Different scale and type of housing providers are needed for fulfilling different demands of different client groups. Lower order of technology is cheaper and easier to use. A large setup, or financial and organizational outlays are not necessary for all agencies providing housing. As a result of all the above factors, entry in the building industry is easy, and small firms with scanty resources and limited technical and financial capabilities proliferate. Small firms with no execution capacity of their own, encourage the practice of sub contracting work, which along with lower wages justify the continued use of archaic methods of construction. The traditional image of building construction is that of a series of manual activities, which is true to an extent even today. But at the same time, today, the demands of economy, accuracy, quality, and timely completion of projects and use of new building materials has made mechanized operation, sophisticated plant and instrumentation, and superior construction techniques necessary. Correspondingly, a need of higher level of skills of the workforce is becoming more obvious (Shah 21), all the more so in the rapidly growing urban metropolises.

3.2 Construction Activity in the Pune region:

Pune is a fast growing metropolis the in the state of Maharashtra, in western region of India. It is located at a distance of 180 km from Mumbai. Due to its proximity to Mumbai and its location on the prime transport routes linking other parts of the state and the country, many industries have established themselves in its industrial areas. It is also a center for learning. As is characteristic with most large cities in the country, Pune has a dense and crowded core. Lack of space in the core area has pushed new development on

the outskirts of the city. The city has outgrown its corporation limits. Uncontrolled, informal and illegal building activity has taken place in these fringe areas. Dwelling units built in the city are of various types. There is a large market for builder- developer constructed flats in medium rise buildings (3 to 10 floors). Single-family independent bungalows are also built. Informal housing is characterized by single or multifamily single or multistoried permanent (pucca) dwellings of modest sizes. The various agencies responsible for the development of the various types of dwellings are described later in the chapter. With the increasing population the demand for living is increasing day by day. Since demand is always greater than supply the builder dictates the market and keeps prices higher than the normal level. The builder is not compelled to operate optimally, to adopt sophisticated techniques to improve productivity through skill formation, and thus control the price rise. Also construction costs are much lower as compared to land costs, thereby reducing the investment required for construction. As a result many medium to small size firms can operate in this field. These firms tend to organize their operations on a relatively smaller scale using relatively less capital and more labor. Consequently the technology used is labor-intensive small-scale technology (see Kumar).

Small contractors do not hire construction workers permanently. For lack of continuous work and limited duration of work for each trade the most common method of recruitment of workers is through labor sub-contractors. Labor sub-contractors are people who provide only hand tools and workers and act as a link between builders and workers. There scope of work does not include providing materials and equipment. Kumar has stated two methods of engaging labor sub-contractors. 1: the building contractor pays a

lump sum amount to the labor sub-contractor supplying labor. The lump sum is based on a piece rate. The sub-contractor pays laborers after retaining his own margin. 2: building contractor decides number of laborers required and wages of workers of different trades. Accordingly he forms a wage bill including the labor sub-contractors margin. Workers may pay a commission to the labor sub-contractor in both the cases in exchange of employment received. The system of working through a labor sub-contractor helps workers to move within the local markets to overcome intermitent work availability. Unskilled and semiskilled labor uses this system the most. Masons and concrete workers are among the skilled workers who use this system more frequently. Most of the other skilled workers are freelance.

This chapter gives a general idea of the construction activity according to the different trades involved. The construction activity is divided into six trades mentioned earlier in the first chapter for the sake of ease of communication to the reader. It should be noted while reading this chapter that that everything mentioned herein is a broad generalization and represents the construction practices and situations in most instances. There would naturally be exceptions to the case. Also the type of construction activity described here is prevalent in a wide range of buildings- from expensive bungalows to one-room houses. Most slum dwellings would not fall under this category but most of the buildings in the informal settlements would show remarkable similarities in the construction process.

3.3 Construction workers:

As mentioned earlier, construction workers are either recruited by labor sub contactors or are directly employed by the builder/ client. Although workers employed by the sub

contractor have the advantage over the independent workers of finding jobs through him without searching for them in the market, none of them are employees of the sub contractor or the builder. In this regard, all workers are equally unsure of continued employment. The main reasons cited for builders and contractors not employing workers permanently are (Kumar) 1: limited duration of work 2: discontinuous demand 3: shifting worksites. As a result, earnings are lower than other industrial workers.[33] The economic condition of most workers is poor and characterized by meager wages, greater number of dependents and lack of education and training. Holidays are not paid nor do they have any paid leave. Work on the sites is demanding for trades like concreting. A lot of exhaustive physical labor is involved. A typical working day starts at 8/9 a.m. and ends around 6 p.m. with a one-hour break for lunch. Workers continuing work in the nights with no extra wages, is not uncommon. Working conditions on the sites in many cases are not appropriate or adequately safe. Workers are often exposed to rain and sun. There are no safety measures taken neither by the employer nor by workers themselves. Even minimum safety gadgets like boots or helmets are not provided. Accidents sometimes lead to death. Many workers work with minimum tools that are not in proper conditions. Kumar reports of many workers suffering from physical ailments. He also reports fast aging of construction workers.

Construction workers are not organized under trade unions due to the discontinuous and shifting nature of their employment.

[33] Kumar states the individual monthly earnings of construction workers in Pune ranged from Rs.2000 (US $46.5) to Rs.3000 (US $ 70) in 1995. He further states that 60% to 80% of the earnings are spent on food and fuel while 5% to 10% are spent on smoking, betel and tobacco chewing etc. Income spent on drinking is not disclosed by workers.

3.4 Producers of Housing:

Housing production may be attributed to three large-scale types of building agencies viz. builders (building contractors), Government or other institutions and individual clients.

Builders:

These form the bulk of the private sector housing producers. It is very difficult to describe a builder. Characteristically a person teaming up with a financer to buy land, build on it and sell the flats (ownership kind residential units in a building) is termed as a builder. Although a builder is responsible to buy land, make building plans, get them approved and construct them, it is the financer who plays an important role. Typically he is interested in getting returns and therefore may not be committed to this trade if something else pays more dividends, stalling the construction project as a result. The person teaming up with the financer may be an experienced building supervisor or a building contractor or even a first time entrepreneur. Other than these types, there are builders committed to and established in the trade. They are usually large enterprises, are dependable and may also be known for their quality of construction.

Government and other agencies:

Government agencies, organizations like the railways, army, navy, air force, telephone, banks, and insurance agencies, and a large number of companies in the private sector build housing or even townships for their employees. Cooperative societies formed by various groups also build apartments. While some of the Government agencies may have their own civil works departments, others engage professional agencies- architects and contractors- for construction.

Individual clients:

Private houses ranging from large bungalows to modest one-room houses or even multistoried buildings are built by individual clients without engaging a builder. A building contractor may be engaged directly by the client or in case of small jobs workers maybe directly employed. Sometimes a worker takes up the responsibility of constructing the entire house and engages other required agencies for various jobs thereby acting as a contractor.

3.5 Trade 1: Concreting:

Reinforced Cement Concrete (RCC) is the most widely used form of concrete. Single storied one-room structures to multistoried buildings all use RCC as their structural component. Many elements of a building are built in RCC. These include foundations, beams, columns, floors, roofs, weather sheds, lofts, stairs etc. RCC has been a technology that has been in use for the last fifty years. The technique has been so widely used that it has nearly become a vernacular technology. But unfortunately, in the process, despite wide use, the technology has declined in quality and proficiency instead of improvising and sophistication. The safety factor of 3 in the design of RCC is a major factor in its wide adoption. Despite poor quality, inferior materials, improper execution and absence of technical design, RCC rarely fails as a structure. In fact, this apparent invincibility has made people perceive RCC as the strongest and the most permanent material for construction and hence the popularity. Alongside has developed a notion of prestige associated with building with RCC, especially in the lower income groups.

Cement, sand (fine aggregate), coarse aggregate, and steel are the basic materials required. 43 or 53 grade gray cement is the most commonly available. It is interesting to

note though that 53 grade cement is preferred for any application by most- most of whom who are clueless about its technical qualities but are convinced that a higher grade cement is more permanent and durable and therefore the first choice. Coarse aggregate is locally available from quarries[34]. Usually 25mm to 30mm size is used. Mixing different sizes is not a necessary practice. Fine aggregate (sand) is obtained from riverbeds. Steel is mostly recycled steel. Graded steel is only used by quality conscious and economically well placed builders.

A typical RCC work begins with casting of foundations and columns followed by beams and slab. The work can be sub divided into a number of activities like bar bending, erection of scaffolding, laying of reinforcement, erection of formwork, and concreting. Each activity is done by a different team of workers. Bar bending starts much ahead of the actual concreting. It is a tough physically demanding job. Usually a single bar bender is employed with one or two assistants. Bending also includes cutting of bars to the required sizes. Bending is done on site on the ground and a wooden bench with the help of a heavy hammer and a chisel. Bar benders work for the full day in the open. A bar bender may or may not be able to read or understand the drawings and tables of the engineer. The site supervisor orally explains him the job in terms of number of bars and their lengths and shapes.

Shuttering for the concrete is erected by a separate set of workers[35]. The person responsible to erect the formwork for all the RCC components is called a carpenter. He is the only skilled worker needed for the entire operation. He is required to understand the depths and positions of beams and columns and accordingly put the formwork in place.

[34] Stone available in the Pune region is basalt.

The material used for formwork is usually wooden planks except for slabs where steel plates are used[36]. Hence the name carpenter. The carpenter also lays and ties the reinforcement. The carpenter should thus be able to understand drawings and read the numbers (many carpenters are illiterate except for reading numbers) In this respect, erecting formwork for staircases is perceived as the most difficult task as it involves some calculations to be done by the carpenter.

Shuttering material is mostly wooden planks supported by bamboo or wooden posts[37]. Steel plates of size are used for slabs. Steel plates are made of a steel sheet fixed on a steel frame of 25mm x 25mm angle sections. Steel plates ensure easy removal, prolonged use and better finishes than wooden planks but most of the times have bulging or depressed surfaces on account of rough handling and inadequate gauge of the steel sheet used. Wooden planks are more flexible as they can be cut to required sizes and shapes. The supporting bamboo or wooden posts too can be cut whenever necessary. But to avoid cutting, they are made available in lengths of 2.4m –2.7m which is slightly shorter than the usual room heights. Bricks or stone tiles are placed under them to lengthen them when needed.

The cut and bent bars are placed on the formwork by the carpenter. Bars are tied to each other by binding wire[38]. Pieces of coarse aggregate are placed under the bars to act as stools for the required cover.

Concreting is a major activity. Concreting of slabs especially is considered the most important activity in the building process. Concreting of the slab starts with a small pooja

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[35] Shuttering is owned by a shuttering contractor who leases it to the builder/ client or by the builder himself. Carpenters or concreting workers rarely own shuttering.

[36] Wooden planks cover remainder areas not covered by steel plates. Joints and gaps are filled by newspaper.

(God worship) and is done at a stretch except for very big slabs where it may be done in parts. A concrete mixer tied to a bullock cart or a jeep is brought to the site. The mixer is a simple machine with a rotating drum wherein all ingredients are manually pored. The rotating drum mixes the ingredients and pours the mixture on the ground. From there it is filled in ghamelas[39] and carried over the head to the place where it has to be poured. There is a particular method of pouring concrete in slabs. The concrete is thrown on the slab with a swirl of the ghamela so as to spread evenly on the surface. A plate vibrator is used to compact the poured concrete while a rod vibrator may be used in some instances for columns and beams. There are many sites where compacting is manually done by a hand compactor and a steel rod. Also, concrete mixers are only used for slab work. For all other work, concrete is mixed manually on the ground. For small and low cost construction, even concrete for slabs is hand mixed. Proportions of different ingredients are by volume and measured on site in terms of number of ghamelas and buckets of water[40].

Casting of slabs can be also taken up at night to avoid the sun or in some cases traffic. Curing of slabs is done by maintaining a thin film of water over the slab by building small bunds of mortar. Other RCC work is cured by occasionally watering it with a bucket of water or a hosepipe where available.

A big team is needed for concreting jobs. The job does not require skilled workers and the major part of the job is transporting material- raw material to the concrete mixer and mixed concrete to the place of pouring. A large number of women are involved in this job

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[37] Entire steel shuttering is expensive and therefore hardly used.
[38] If desired by the client, for concealed wiring, electrical conduits are laid by the electrician at this stage.
[39] A ghamela(s) is a shallow metal container/ pan @38mm in diameter and 110mmdeep.

too.[41] In case of carrying concrete to upper floors, a scaffolding of bamboo and wooden planks tied by ropes is erected for the workers to stand on and pass the ghamela from head to head. The whole process of concreting is well synchronized and each member of the team knows his/ her role. It is a team effort unlike any other skill and hence the team leader needs to be sure of the participation of his team members in all projects. As a result, teams are formed on the basis of family relations, and old home place acquaintances. Large groups of unskilled laborers come from Karnataka and Andhra Pradesh for this job and are mostly tribal called 'Wadaris'. Men and women both work in the team. Wadaris are characteristically nomadic, wandering in search of work from one city to another, physically tenacious, uneducated and illiterate, prone to addictions like drinking and tobacco chewing and non-conversant with the local language. They do not lead settled lives even after earning a fair amount of money. Other than Wadaris, teams from other poorer states like Orissa too do concreting work. Local concrete workers are lesser in numbers as compared to these migrant teams.

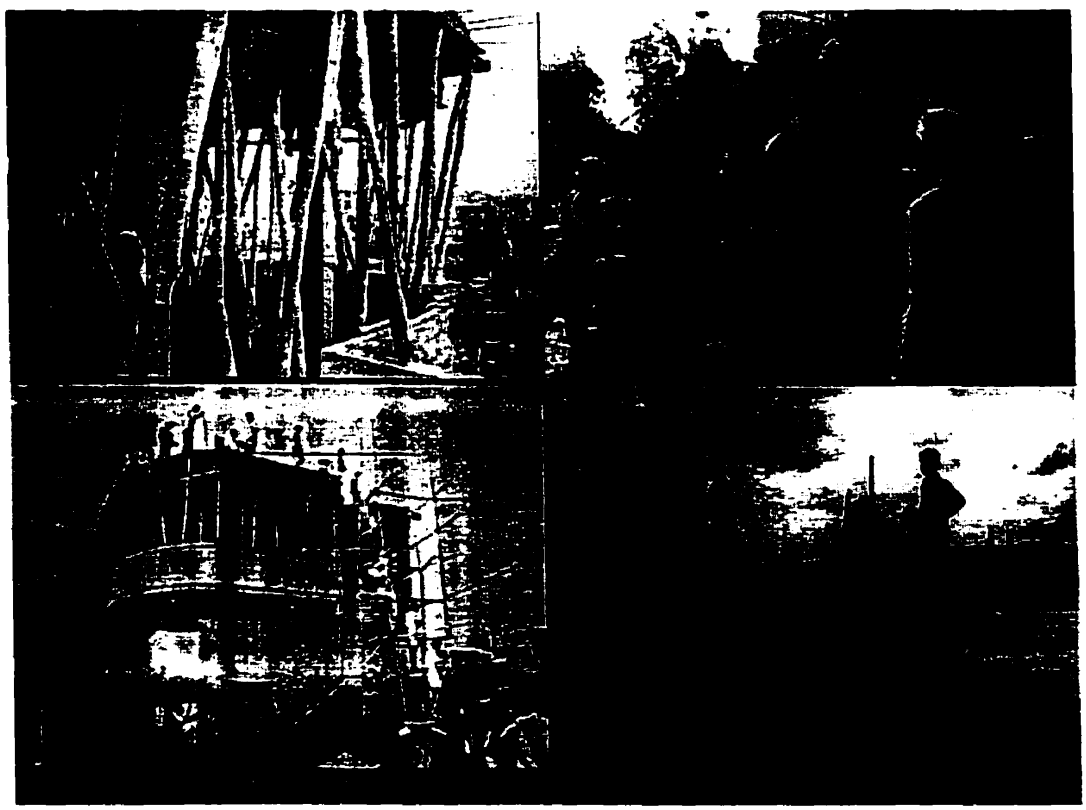
Thus the entire RCC work requires four kinds of workers- the bar benders, the carpenters, the concreting workers and the workers to erect the scaffolding. The concreting workers are the largest group and are mostly employed through a sub contractor (refer 3.2). Carpenters may be directly engaged. Carpenters are paid on a daily basis @ Rs. 200/- to Rs. 250/- (US $ 4.6- 5.8) per day while their helpers are paid @ Rs. 125/- to Rs. 150/- (US $ 2.9- 3.5) per day. Concreting workers are paid @Rs. 125/- (US $ 2.9) per day. The

[40] While the size of the ghamela may not differ much from site to site, the size of the water bucket does, so that the proportion is only approximate.

[41] Concreting and masonry are the only building trades that employ women as unskilled laborers. No other trade has women workers- skilled or unskilled.

Typical RCC construction of residential building

The process of concreting



team leader of concreting workers may charge a lump sum amount based on the amount of work and then pay his team members on a daily basis.

RCC is a technology that depends on qualified structural designers for its use. But today, there are many instances where RCC is used without employing any qualified people. Most of these works are done on the basis of the carpenter's or the contractor's know how. Even when qualified designers are employed, they restrict their role to deign consultancy without than on site work. Supervisors, either qualified or non-qualified are the responsible for the site work. Workers have no reason to care for accuracy and quality of work unless it is strictly demanded of them. Few engineers go to the construction sites, fewer check everything and instruct the workers, and fewer still demand strict compliance with proper procedures and quality standards. As a result, mistakes like shifting of column positions, and defects like honeycombing of concrete, exposure of reinforcement due to inadequate cover etc. are not a rare occurrence. Engineers who go on sites restrict their role to checking slab reinforcement.[42] Sometimes they may be present during casting of slabs.

3.6 Trade 2: Masonry:

Masonry of sun dried mud bricks or stone has existed since a long time. Masonry was either done in mud or lime mortar. Making lime for mortar was a long and laborious process. Masonry was mostly structural, carrying the weight of the floors and walls above. As a result, wall thickness often exceeded 300mm and may reach up to 1000 mm. Walls were plastered on both sides. When burnt clay bricks were used, brickwork could

be left exposed on the exterior faces. In such instances, decorative patterns in brickwork ornamented the facades of buildings. Masonry was a principal building profession and it was a family occupation. Traditional mason families still exist and some even have their descendents continuing the profession today.

Materials for masonry have undergone a change. Cement mortar has completely replaced lime mortar. Brick sizes have changed. Today, burnt clay bricks are the chief raw material.230 x 105 x 75 mm is the standard size of the brick used today. Bricks are manufactured in local kilns or are got from nearby areas in the region. Brick is the cheapest building material with costs @ Rs. 900- Rs 1200 (US $ 20.9- 27.9) per thousand bricks. Special bricks made for exposed brickwork are more costly (@ Rs. 4000- Rs 7000 (US $ 93- 162.8) per thousand bricks) and have a limited market. Bricks are made out of a wooden mould and are hand compacted and hand cut. They are fired by a traditional process that has no sophisticated equipment to regulate temperature or heat flow. As a result, bricks are not exact in size, do not have smooth surfaces, and are not uniformly fired. But since most brickwork is plastered, the defects in the bricks don't matter a lot. It is debatable whether the practice of plastering allows for imperfect bricks or whether imperfect bricks have made plastering necessary. In case of the newly introduced 150mm wide bricks (called thokla bricks) plaster is indispensable. These bricks were introduced as a result of the local authorities granting permission to build 150mm thick external walls for houses. As these bricks save on material cost and space, they became popular among builders. But as mentioned earlier, the inferior quality and the use of single brick for the wall, makes them unusable without plaster.

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[42] The cost of correction compared to the cost of letting the mistake pass may discourage a contractor to heed to the engineer's advice. Also, the "let it be" attitude of both, the contractor and the engineer may

Concrete block masonry has also gained acceptance in the market but the process has been slow. Concrete blocks were introduced to overcome the drawbacks of brick construction like non uniformity of bricks, small size of bricks and therefore the large quantity required, more number and thickness of joints, etc. But despite these disadvantages, brick construction is still popular and favored equally by both, clients and workers. A study in Pune showed that bricks were the favorite walling material of 75% builders in the city, while 25% used both bricks and concrete blocks. No builder was found to use only concrete blocks in his work[43]. Even 66% architects and engineers recommended only bricks while the rest gave a preference to bricks. Most importantly, it was found that masons purposely worked slowly with concrete blocks to prove its disadvantage in speed and economy. They also increased the plaster thickness for concrete block masonry. The resistance was found mainly due to the blocks being heavy and cumbersome to handle (Khatkhate, 96). Alternative materials like foam concrete blocks or fly ash bricks are also available but their use is seen only in exceptional cases. With the introduction of RCC as a structural material and its use as a structural frame, most masonry work has been relieved of its load carrying duties. Infill walls are very common. This has led to the reduction of wall thickness. Stone masonry has been reduced to masonry in foundations and plinths or some decorative elements[44], as it is costly and unnecessarily heavy and space consuming[45]. Load bearing structures are built too using burnt brick masonry.

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make them ignore the mistake even after identifying it.

[43] This is especially true after the introduction of 150mm wide bricks.

[44] Compound walls, retaining walls, built landscape elements and some other auxiliary elements could be done in stone masonry too.

[45] Engineer Vishnu Joshi has designed and devised a new technique for building thinner stonewalls. This technique termed as stone concrete uses medium size stones on the outer face of a poured concrete wall.

But with the change in materials, the technique of masonry has not changed much. A mason works independently with one or two helpers, either male or female. A mason works for 8 hours a day from @ 9.00 am to 6.00 pm (with a lunch break). On an average, a single mason can build approximately 5 sqm. of half brick wall not exceeding 3 m in height in a day. For most projects, one mason is enough to complete all the brickwork.[46] The mason does only the skilled job in the process. He lays bricks and mortar ensuring plumb and level for the whole masonry. Helpers do all the rest of the work. One helper mixes the mortar and carries it to the mason in ghamelas as and when required. The other helper carries bricks (on his/her head) to the mason. Thus, the mason has a privileged position in the team and the others are subservient to him. It is no wonder then that the mason is reluctant to teach a helper any skill if the latter wishes so. There is a considerable wage difference in a mason's wages and those of his helper. While a mason earns @ Rs. 200/- to Rs. 250/- (US $ 4.6- 5.8) per day, his helper earns @ Rs. 125/- to Rs. Rs. 150/- (US $ 2.9- 3.5) per day (women helpers earn @ Rs. 100/- to Rs. 125/- (US $ 2.3- 2.9) per day). But there are masons who informally train an apprentice on their work sites. This is not a systematic teaching and usually depends on the apprentice's capacity to observe the mason work and to reproduce it when given a chance with occasional comments and instructions from the mason. A mason may ask his helper to do a small part of his job while he is taking a break for tea or chewing tobacco, etc.[47] This is the method by which most of the present masons have acquired their skills.

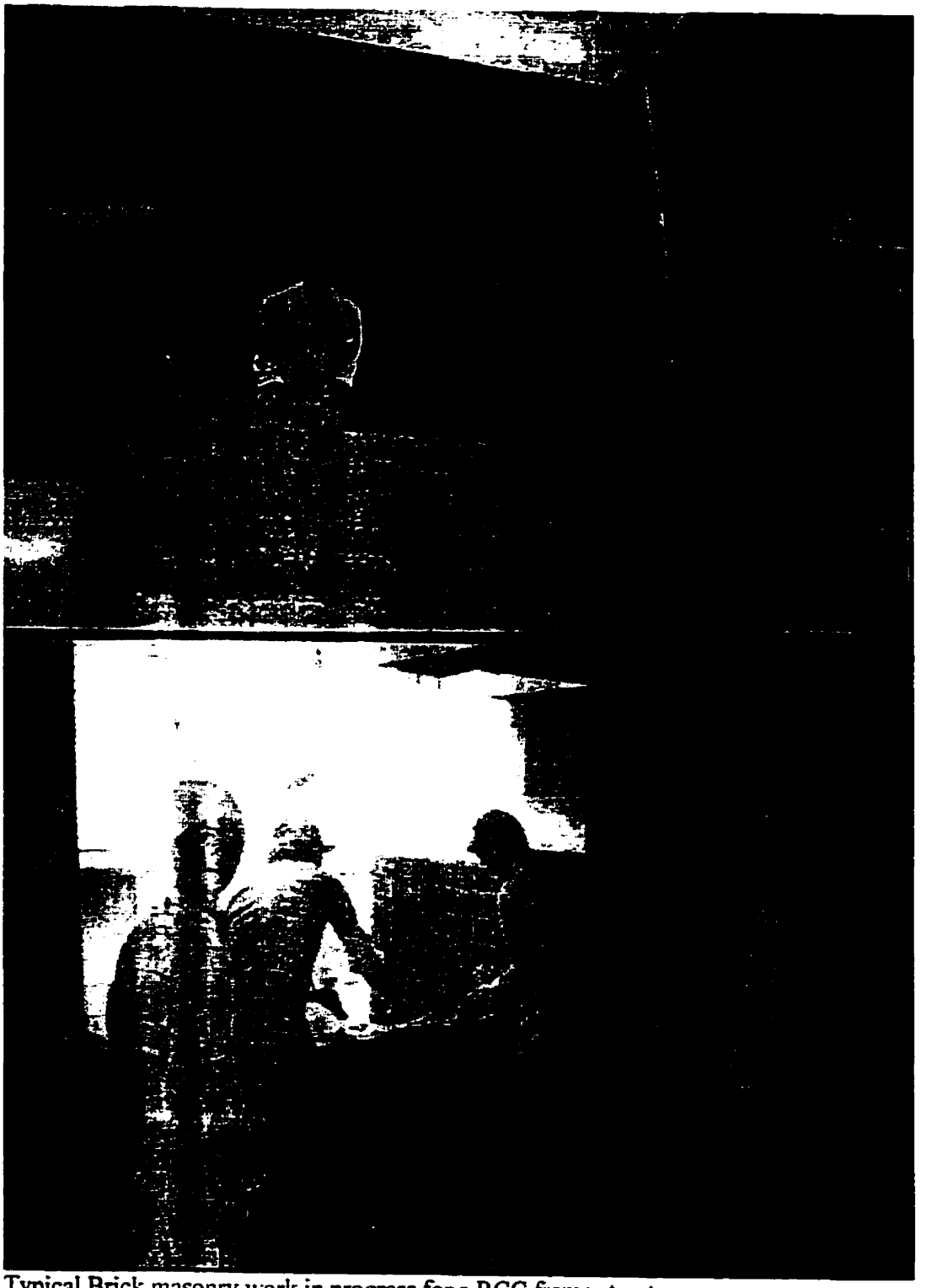
This wall thus has a smooth inner finish and a stone face exterior. The thickness could be reduced to as low as 200mm. One of the workers studied in the sample for masonry uses this technique.

[46] Brick work being the major component of any building

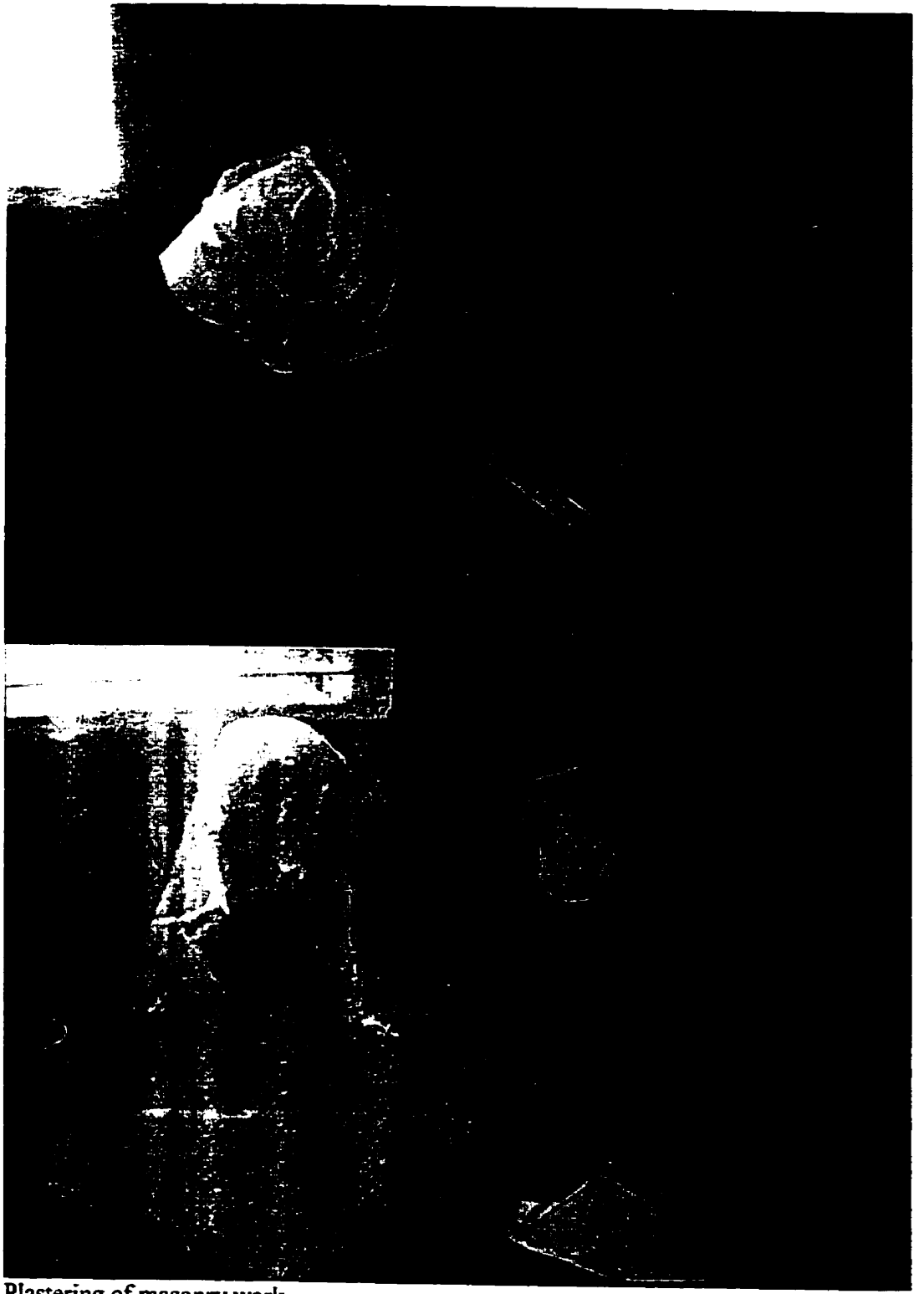
[47] Woman helpers are never asked to do such jobs and made apprentices.

None of the tools used for masonry have changed or improved even for masonry with new materials like concrete blocks. Much of quality and accuracy depends on the skill of the mason and there are limits to the accuracy of manual skills. As a result, walls are seldom plain, in perfect plumb or level. The quality of bricks is rarely to a level where it can be more or less waterproof and weather proof. Plastering thus more or less becomes a necessity rather than choice. An average of 25 mm thick plaster from the inside and 35mm thick plaster from the outside is applied. Internal plaster is finished with neeru while external plaster could be sand face or any other rough texture. Masons also do the plastering work. Hand tools like trowel and wooden float are still the only tools used for plastering work. Masonry work has neither undergone any mechanization nor sophistication.

H.G Wells writes "The chief ingredient in this particular house wall is the common brick, burned earth, and but one step from the handfuls of clay of the ancestral mud hut, small in size and permeable to damp. Slowly, day-by-day, walls grew tediously up, to a melody of tinkling trowels. Everything in this was hand work, the laying of the bricks, it is a dabbling of the plaster, the smoothing of the paper, it is a house built of hands and some I saw were bleeding hands- just as in the days of the pyramids when the only engines were living men. The whole confection is now undergoing incalculable chemical reactions between its several parts. Lime, mortar, and microscopical organisms are producing undesigned chromatic effects in the paper and plaster; the plaster having methods of expansion and contraction of its own, crinkles, and cracks; the skirting, having absorbed moisture and now drying again, opens its joints; the rough cast coquettes with the forest and open chinks and crannies for the humbler creation. I fail to see the necessity of (and



Typical Brick masonry work in progress for a RCC frame structure



Plastering of masonry work

accordingly, I resent bitterly) all these coral -reef methods. Better walls than this, and better and less life -wasting ways of making them are surely possible" (Wells 66-67). The condition in India is not very different. But still, brick masonry is the cheapest, fastest and the easiest way to build in this region.

Apart from masonry, masons also do jobs like laying simple flooring (shahabad stone tiles or marble mosaic tiles), building kitchen platforms (of kuddapa stone sheets and brick masonry), and waterproofing of roofs (brick bat coba type). As a mason is proficient in executing most of the major items in house construction, some masons also take up jobs of constructing the entire house. For items like roofing (usually sheet roofing in such cases) other professionals are engaged by the mason. Thus the mason here becomes a contractor working beyond his trade skills. This type of work has a major clientele in the low-income formal and informal housing.

3.7 Trade 3: Carpentry[48]

Carpentry is a traditional skill. Before the advent of RCC, wooden post and beam structures with mud or brick infill walls[49] were prevalent. Roofs too were primarily made of wood and covered in clay tiles. The most commonly available wood in this part of the country was teak, babul, etc. Carving of wooden columns, brackets, arches, doors and windows was a common form of ornamentation. Most of whatever little furniture the houses had was wooden and carved. But wood became more and more rare and hence,

[48] Workers making wooden shuttering for RCC work are also called carpenters. These are not considered here though. They are represented in the thesis under concrete workers, although they rarely do the actual concreting. The reason for not considering them under carpentry is that their skill and type of job is very different from that discussed here and there is very little overlap of working methods or working conditions in the two.

[49] Structural systems could differ in wooden structures. Composite structures with load bearing walls and wooden posts and beams were very common.

costly, and soon had to be abandoned as a construction material. Also, the new option of RCC overcame to a large extent the disadvantages and limitations of wooden structures. Wider spans, taller structures were possible. The termite and rotting problem of wood, its susceptibility to fire, its demand for regular maintenance was no longer the considerations for RCC that was more robust.

Wood, today, is a major material for interior finishing and furniture. Solid wood is now replaced by plywood, block board, particleboards, etc. though wooden members may be used where affordable[50]. The more recent market entrants are MDF boards and gypsum boards. Finishing of wooden surfaces has subsequently changed to laminates, veneers or paints. The most common wooden elements to be found in a building today are doors and windows, partitions, cupboards and most of the other furniture. Tools for carpentry have undergone a change too. Traditional carpenters have a large repertoire of tools. Almost all of these traditional tools still remain in use, especially by carpenters trained under family traditions of the trade. The replacement of hand driven tools by power tools is the major change that ha taken place. Power saws, drills, molding machines etc. are being used even by traditional craftsmen. Joinery has undergone some changes. New adhesives and hardware are introduced in the market every now and then.

Carpentry, traditionally, was a family profession. Traditional carpenters are found in every region of the country, as carpenters were one of the twelve 'balutedars[51]' that each village had. But among all, carpenters from Rajasthan are the most well known and sought after for their finesse and prompt work. Rajasthan is a state where building crafts

[50] Wooden members are usually in the sizes of 25mm x 25mm to 100mm x 100mm. Bigger sections could be available from sawmills. Wooden planks are nearly out of use. Lipping strips ranging from 3mm x 12mm to 3mm x 50mm are also available.

have excelled over centuries. Carpenters here belong to the caste of carpenters and enjoy a unique and important position in the building activity. These carpenters are also ironsmiths and masons. Thus they are a major agency in house construction. Being ironsmiths, they also make and repair their tools. But most of the carpenters have shunned their masonry skills and restricted themselves to carpentry. Carpentry is less laborious than masonry and has a better social image. Ironsmithy has slowly dwindled as a profession as fabrication replaced it. Consequently the iron smithy skills of carpenters are restricted to manufacture and repair of some of the tools for their own use. Carpenters from Rajasthan migrate to many cities throughout the country in search of work. Working in cities implies better earnings, better exposure and better social status back home. Distress migration is less visible in carpenters, especially from this state. The major change that the migrant carpenters encounter is a change in material- from wood to ply wood. The behavior of plywood and the technique of using it are both different from solid wood carpentry. But, interestingly, tools do not change. Newly arrived carpenters work under an already settled mistry till they learn the craft. Some may continue to work under the mistry while some may leave and form a team of their own. Nowadays, not only traditional carpenters but other people from Rajasthan too migrate to cities and train themselves under traditional mistrys to become carpenters. All help each other to find work or employment and help the ones having bad times. Team members live together in a place usually provided by the team leader. But Rajasthani carpenters are a closed group. No carpenter or apprentice from other regions is accepted in the team. Team leaders meet each other once in a month and keep track of each other but there is no contact with

[51] The 12 balutedars were twelve trades needed by a village. One family practicing each trade lived in the village and catered to its needs. They were entitled to a portion of the yearly crop from the landlords in

carpenters from other regions. Rajasthani carpenters also have a unique style of working. They usually live on their work sites and work from early morning till late night. They cook their food there too. A majority of the carpenters are nondrinkers. They migrate to the cities without their families and thus have no commitments other than their work. They take turns to go back to their native villages once or twice a year for a month or so. Usually these carpenters are conscious of the qualities that make them popular in the market and strive to be the best among all. Most of them hold the carpenters from other regions in contempt, especially the local carpenters.

Local carpenters (including those from other parts of Maharashtra) lack the team spirit of carpenters from Rajasthan. They are a little inferior skill wise (though some may be equally or more skilled). They have an 8-hour working day. Also, drinking and the resulting absenteeism are not uncommon.

Today, there are many first or second-generation carpenters. Carpentry is also taught in industrial training institutes (ITI). Carpentry is a profession that could be practiced individually or as a team. Both, a single carpenter and a large team, are available. Almost all jobs are executed on site and carpenters rarely have workshops of their own[52]. Usually all carpenters execute all kinds of carpentry jobs; specialized practice is rare[53]. Carpenters charge their fees as a percentage of the total cost of material used. The percentage may range from 25% to 40% of the entire material cost, including cost of finishes and

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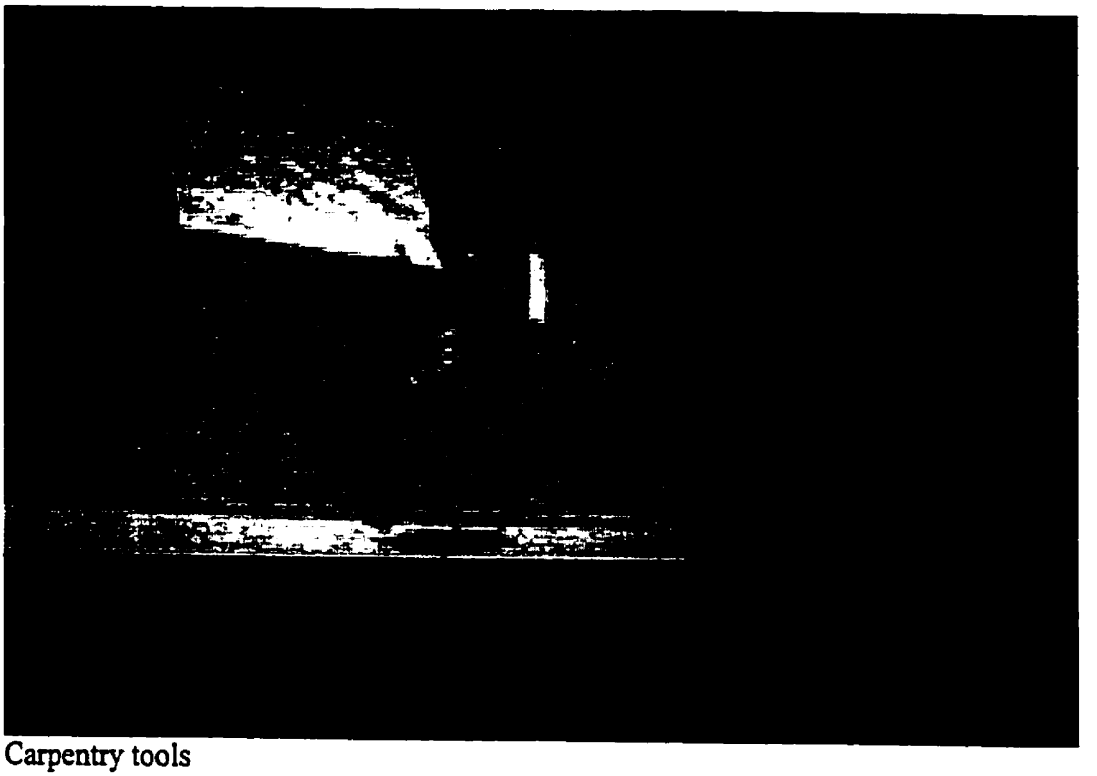
exchange of their services for them.

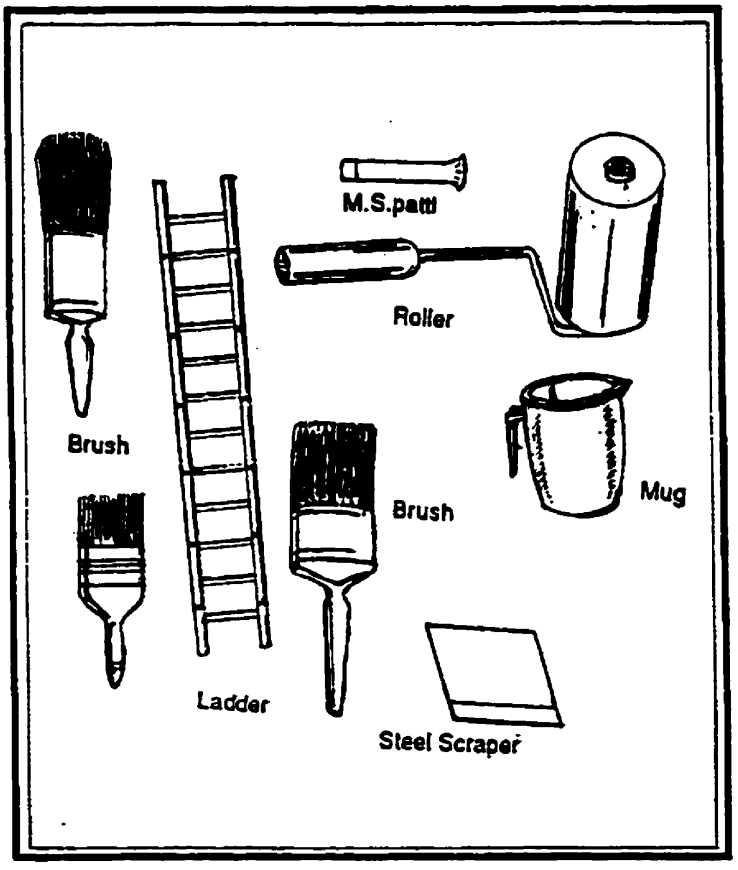
[52] Rajasthani carpenters also usually stay on the site if possible during the course of the work and work in the nights too. Though workers may be paid as per shifts, the client is charged in terms of percentage of the total material cost and not on working days.

[53] There may be some carpenters who work for bulk orders of items like door and window frames for builders. These carpenters would not usually divert from such jobs for their obvious advantages. But if such jobs were unavailable, they would change over to whatever carpentry jobs are available in the market. Similarly, carpenters working under interior designers would rarely take up bulk jobs from builders unless thee need arises. But a majority of the carpenters would be fluctuating between various types of jobs.



Carpentry tools

Tools for Painting



hardware. Carpenters and helpers employed under a mistry are paid on a daily basis. Daily wages for an employed carpenter are @ Rs. 200/- to Rs. 250/- (US $ 4.6- 5.8) and for a helper are @ Rs. 125/- to Rs. 150/- (US $ 2.9- 3.5). Carpentry is more of a skill job than a labor one. Traditionally, carpenters as building professionals are placed higher up on the social ladder than other construction workers.

Carpenters, once, were the key people in building a house- they built most of the important parts of the structure including the roof. It is important to note the complete change that has come about in the role of the profession in house construction- from a major builder to an interior finisher.

3.8 Trade 4: Fabrication[54]

Iron smithy has always been a supporting building profession. The traditional ironsmith was responsible for making tools for carpenters and masons apart from those needed for agriculture. Ironwork was never a major component of buildings. Most of the hardware like bolts, hooks, hinges, nails, etc. and sometimes components like window grills, railings were of iron. Cast iron and wrought iron were the most common forms of ironwork used. Piping was done in cast iron. The traditional ironsmith used a fire to heat the iron and a hammer to beat it to the desired shape. This technique is still used in some places for repair of agricultural tools and other minor jobs, but has more or less disappeared from the big cities. The introduction of mild steel completely changed the old iron trade. The principal change was the process of manufacturing mild steel (MS) components. Mild steel is widely available in industrially manufactured forms like

[54] The skill for making all kinds of steel work (except the steel work in RCC) concerned with homebuilding is termed as fabrication. The skilled worker doing this job is called a fabricator.

angles, square or round pipes and bars, I, T, and C-sections and sheets that are ready to be joined to make various elements for various uses. Joinery is by welding or riveting. Traditional tools are thus no longer useful. Mild steel has far wider applications than cast or wrought iron because of the variety of its available forms and the ease of putting them together for various applications as compared to the laborious process of making wrought iron or cast iron components. Work with mild steel is much faster too. Today, Mild steel is used for door and window frames, safety doors, weather shades, stairs, water tanks, roof and floor trusses and beams[55], fencing, and, sometimes, also furniture, none of which were made in cast or wrought iron. Cast and wrought iron components like grills, gates, railings, and hardware too are today made in mild steel.

Riveting has been mostly replaced by welding. Gas welding was used for many years but nowadays it has been replaced by electrical welding. The common tools required for a fabricator today are cutting, welding and grinding machines, all of which are handy and are power driven. The approximate cost of machines required for setting up one's own business is @ Rs. 25000/- (US $ 581.4), which is not very expensive given the amount of jobs and the cost recovery period. So once trained, many fabricators set up their own business. The level of understanding of the trade is usually low among many fabricators. Many do not understand basics like gauge of the material, length to weight constants and have little comprehension of variations in jobs; most prefer to do routine jobs. But that is not a deterrent for working independently since there are enough clients asking for routine jobs. Fabricators usually do not work in teams but are independent trades

[55] MS beams are not common in domestic construction. But they could be used in extension works or in situations where RCC beams are not possible. Simple MS roof structures are common though, especially in lower income groups, where RCC roof is unaffordable or where the roof needs to be semi permanent.

people.[56] A typical establishment of a fabricator is a small workshop (or even the open space in front of their house). There may or may not be any helpers employed. Most work is done in the workshop and installed on site. If required, the entire work could be done on site too.[57] The work is charged on a sqft (area) basis. Work could be taken up along with purchasing material or just labor. The rate per sqm[58] along with material ranges from @ Rs. 400/- (US $ 9.3) and goes up to Rs.1200/- (US $ 28) as per design and intricacy of work. If the work is taken on a labor rate, the rates vary from @ Rs. 150/- to Rs. 250/- (US $ 3.5- 5.8) per sqm. Fabricators complain that while the prices of steel have more than doubled in the last ten years, the sqm rate given to the fabricators has remained the same thereby decreasing their income margin. Fabricators pay their staff as per the skill of each individual. A skilled worker usually earns @ Rs. 125/- (US $ 2.9) while an unskilled worker earns @ Rs. 70/- (US $1.6). A novice earns @Rs. 40/- (US $ 0.93). Welding skills are also taught in industrial training institutes (ITI). Very few of those though work in the home building sector. Fabricators employing some ITI trainees are of the opinion that the trainees have a very theoretical knowledge of the trade and are weak on skills.[59] They also demand more pay than other apprentices and skilled workers.

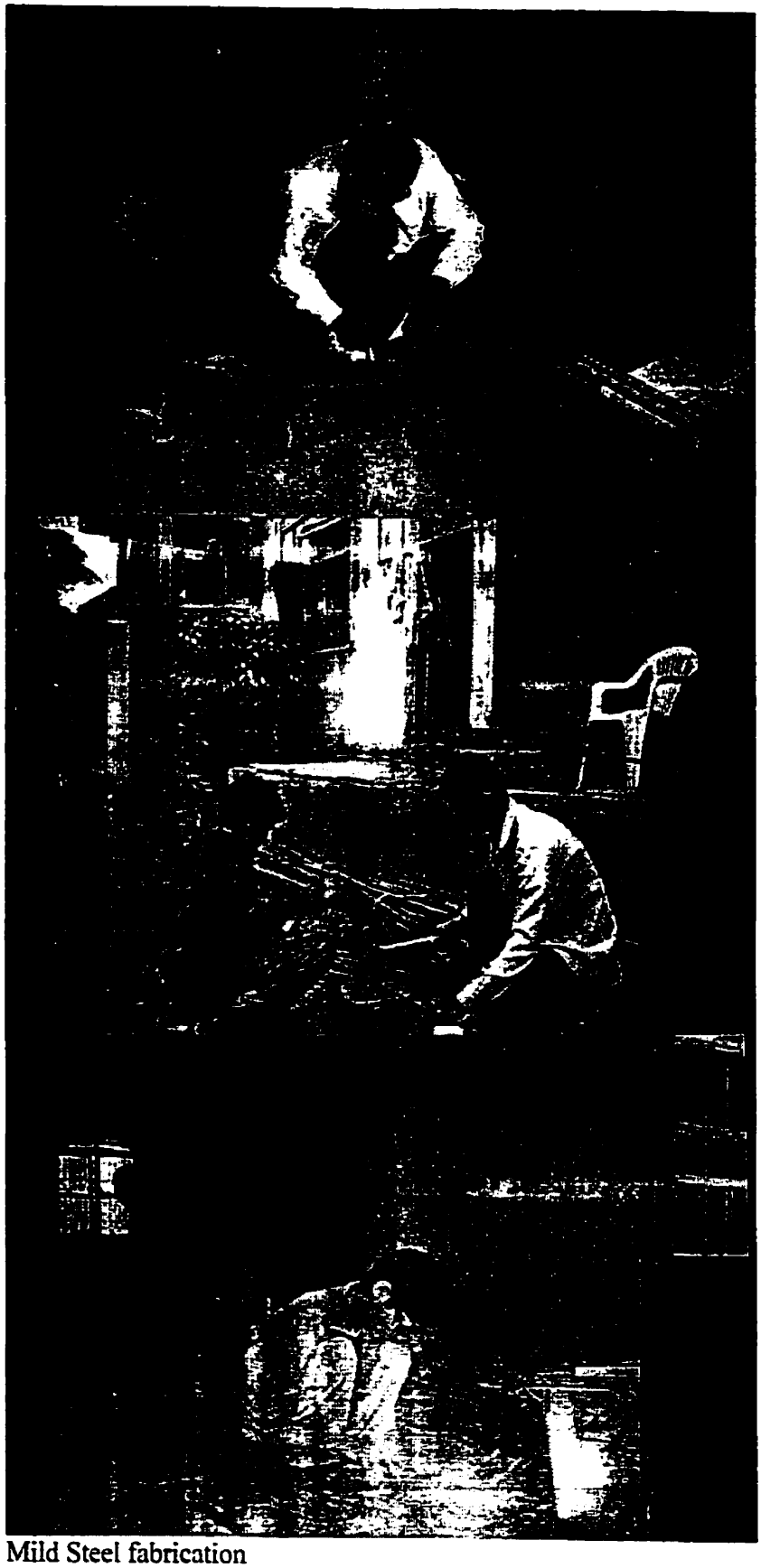
This roof is generally covered with galvanized iron (GI), Asbestos Cement (AC) or Fiber Reinforced Plastic (FRP) sheets or burnt clay tiles.

[56] Independent worker does not strictly mean single person but denotes a situation where there is one skilled worker and one or two semi-skilled and/or unskilled assistants.

[57] Work like erecting sheds, fixing fencing posts, etc. are done on site while doors and windows, grills, gates etc. are made in the workshop and installed on site.

[58] Here, the measurement used is sqft.

[59] A fabricator illustrated this point thus: If a 35mm x 35mm x 5mm angle section is to be cut into two parts, the usual procedure would be to use a chisel and a hammer and then bend thee section till it breaks. ITI graduates would use a hacksaw. While the former procedure would take a minute or two, the latter would require at least ten to fifteen minutes. The latter would be definitely a more accurate and finished job than the former but this level of accuracy if weighed against the time it costs, is not affordable, not needed and therefore not prevalent in the field. Similarly, checking levels and measurements every now and then as taught to the ITI graduates too increase the time taken to finish the job. Though it is an ideal procedure to be followed, it is uncalled for in practice.



Mild Steel fabrication

The common forms of MS used are angles, square or round pipes and bars, I, T, and C-sections and sheets of various gauges and sizes. Perforated metal sheets are also sometimes used.

Fabricators working for building construction may also rarely take up non-construction related industrial job work. But usually, they remain limited to the construction activity. Like carpenters, fabricators too show very little specialized practice. Some may concentrate on bulk production of components like door and window frames but that does not necessarily exclude him from accepting other jobs. Such bulk producers may be either sub contractors for builders or may be entrepreneurs selling their own products.

A slightly different application of MS is building of kiosks that may be all steel or a combination of steel and wood. Construction of lofts or floors with steel stanchions, beams and infill panels or cast in-situ slabs is another occasional application[60].

3.9 Trade 5: Flooring and Painting

Flooring:

Flooring has evolved a lot with regards to materials over the last fifty years. While mud floors were common in many houses earlier, stone tiles started finding application over this period. The most common stone used was rough shahabad with tiles of sizes 450mm x 530-600mm or 530-600mm square. Lime mortar was used to fix these tiles over a mortar bed. Indian patent stone (IPS) flooring was also used. This was a flooring made of a cement concrete (1:2:4) bed finished with a cement paste 2-3 mm thick. Mosaic tiles developed as a cleaner, more durable and better-looking alternative and are still widely used today. Mosaic tiles were cement based and had marble chips in them. A huge

variety of tiles have developed since with the cement bases offered in white or various colors with various sizes and colors of marble chips in them. An insitu marble mosaic flooring could also be done. More decorative and costlier floorings have been introduced in the market on a large scale since the last 15 years. These include kota stone floorings (matt or mirror polished), granite and marble floorings. These are used in higher end projects, as both, material and labor costs are high. Laying these floors is a craftsman's job, as the stones have to be cut on site with hand tools[61]. Traditional Rajasthani craftsmen excel in this job. Recently, ceramic floor tiles have flooded the markets too. These tiles of sizes ranging from 300mm square to 600 mm square are available in various colors, designs and shapes. All tiles are laid more or less in the same manner, over a cement mortar base and fixed with cement slurry. Joints are filled with white/ colored cement. Nowadays, adhesives are available to stick flooring tiles to the base, but this method is not widely used. Simple floorings like shahabad and mosaic tile floorings can be laid by masons, while other floorings are laid by separate flooring workers. A single skilled worker assisted by two helpers lays a floor. Polishing of flooring (for mosaic tile, marble and kota stone flooring) is done with a machine by another worker exclusively doing the polishing job. Flooring workers earn the same as other skilled workers @ Rs. 200/-- Rs. 250/- (US $ 4.6- 5.8) per day while helpers earn around half that amount.

Painting:

From white wash to acrylic paints, painting has come a long way in the last five decades. Distemper paints were the earliest paints introduced in the market and are still in use. But

[60] Steel structures are rare in India and definitely non-existent in the home building industry.
[61] Nowadays, some workers use power cutters.

The process of laying flooring and the tools used

today, a wide variety of paints are available- from water based to oil based paints and from matt finish to metallic finish paints. Painting is a finishing item and considered essential to complete the building process. Though, many times, external paint (cement paints) to a house may be unaffordable, internal painting is a near must. And with distemper paints available at low prices and being easy to apply[62], every house is painted. Painting is either done with brushes or rollers. Various sizes of both are available. Rollers with various textures are nowadays available too. Sprays are seldom used for painting walls, but may be used for special paints for furniture. Spray painting is costly though. Procedure wise, painting has not changed significantly despite the new variety of paints. The usual procedure of painting involves surface preparation. This includes sanding down the original paint (or dust in case of a new wall), applying a primer coat, filling in the cracks with putty, and again sanding down the surface to make it smooth and ready to receive the paint. Usually two to three coats of paint are applied depending on the kind of paint used.

Painters usually work in teams. They charge for the job on a square foot basis. Painted areas are measured in 'brass' and the rates per brass are fixed. (1 brass = 100 sqft = 10sqm) The rates vary for different varieties of paints. The team leader charges thee client by the method mentioned above while thee team members are paid daily wages. Skilled workers are paid @ Rs. 200/- to Rs. 250/- (US $ 4.6- 5.8) while helpers are paid half the amount.

3.10 Trade 6: Electrification and Plumbing:

Electrification:

[62] Lay people can and do apply distemper paints by themselves

Electrification of buildings, specifically residential buildings, in a major way came about only around fifty to sixty years ago. Thus the profession of an electrician is an entirely new one without any traditional predecessor. An electrician is a person who carries out the entire wiring job, along with installing fixtures. The State Electricity Board is responsible for all the cabling till a building's main supply. The electrician handles all work from beyond that point. An electrician may not necessarily be formally qualified to do this job but most learn it through practice and experience and training under another electrician. Most of the times, electricians work independently with one or two helpers. An electrician's job may range from petty repairs of household wiring and fixtures to new electrification of an entire multistoried building.

Electrification of a house consists of standard items and requirements. Outlets for lamps and fans, sockets to plug in various devices, and connections for usual gadgets like television, water heaters, refrigerator etc. and the wiring from the main supply for the same is the usual work. Kit-kat fuses as safety device are the most common. There are three different ways in which wiring is done in this region. One is on wooden battens termed as open wiring, second is through open conduits of PVC or metal termed as conduit wiring and the third is concealed wiring where conduits are embedded in walls and ceilings behind the plaster. Cost for each method increases in the order of its listing. Copper wiring is being widely replaced by aluminum wiring.

Since job descriptions do not change much, electricians learn their job with some practice. Bigger jobs for buildings involve some complicated work like distribution boards, earthing pits, etc. and are only done by experienced electricians (experienced does not imply formally trained).

Despite the risk involved in the job, very little safety measures are taken by the workers while working. Rubber gloves, testing equipment, shoes are conspicuously absent. Workers themselves have hazardous practices like putting live wires in a socket to test the current/ use a power instrument and cutting rubber sheathing of wires with one's teeth.

The workday for electricians is from 8 am or 9 am to 5 pm or 6 pm. If jobs are small, electricians may do many jobs on different sites in a day. They charge their fees based on the job. Usual practice is to charge per outlet point. Different types of outlets have different rates. For exceptional jobs, some may base their charges based on percentage of total material cost while in some cases, a labor rate for wiring may be charged on the running length of the wiring done. Helpers are paid on a daily basis @ Rs. 125/- per day (US $2.9).

Many electricians, apart from doing electrification work, also take up repair and maintenance jobs of electrical gadgets like irons, water heaters, stabilizers, water pumps, kitchen gadgets and sometimes even radio and television (if trained). It is not unusual for an electrician to own a shop (even a kiosk) for electrical material. This shop is his workshop, supplementary income and a modestly profitable way of procuring material needed for his jobs. But most importantly, it is his contact place. Even electricians who do not own jobs can be contacted at particular shops. In fact, the surest place to find an electrician is an a electrical supplies shop.

There is a constant flow of new products in this field. Various controlling devices, safety devices, various kinds of switches, indicators, distribution systems, etc. are introduced in the market every now and then, not to mention hundreds of varieties of lamps, fixtures

and other electrical gadgets for domestic use. An electrician needs to be conversant with all these new items. Surprisingly, the tools of an electrician have seldom changed. He still works with basic tools like pliers, various cutters, a drill, tester cum screwdriver and electric tape.

Although an electrician virtually does all jobs related to electricity, there may be electricians who restrict themselves to a particular kind of job. The most common example of such a restricted practice would be electricians working for interior designers. But more than restrictions, one would find them doing auxiliary jobs like appliance repair or running a retail outlet for electrification materials.

Plumbing:

Water was brought from the river or drawn from wells and stored in large containers in the house for daily use. Wastewater was flown in open gutters to a soak pit while night soil was collected in buckets and taken away by scavengers. Though piping in the form of aqueducts or gutters existed, the concept of piping water and waste to and from every house took root only in the early decades of this century.[63] Pipes have undergone a significant change of material during this period. While galvanized iron pipes were used for water supply, cast iron and earthenware pipes were used for drainage. Cement pipes later replaced earthenware pipes while PVC pipes replaced galvanized iron pipes. The most common piping system employed in buildings is an underground tank collecting water from the municipal main, a pump pumping the water to an overhead tank and down take pipes from there reaching individual houses. Variations depending on size of building, number of households, number of users, frequency and pressure of municipal

[63] Piped water and drainage for every household, though a basic amenity in cities, has still not reached most villages.

supply and affordability of the system have one or more components missing from this general system. The usual drainage system is of a waste water pipe from the bathroom and kitchen and a soil pipe from the WC joining the underground municipal drain through a manhole. Septic tanks are used where municipal drains are not available. Plumbers do all work onwards from the connection to the water and drainage municipal lines. Plumbing inside the house may be concealed or exposed. On the external surface of the building, it is mostly exposed. Plumbers apart from doing plumbing work are also needed to do a small amount of other civil work like water proofing of toilets, building inspection chambers and manholes and building septic tanks.

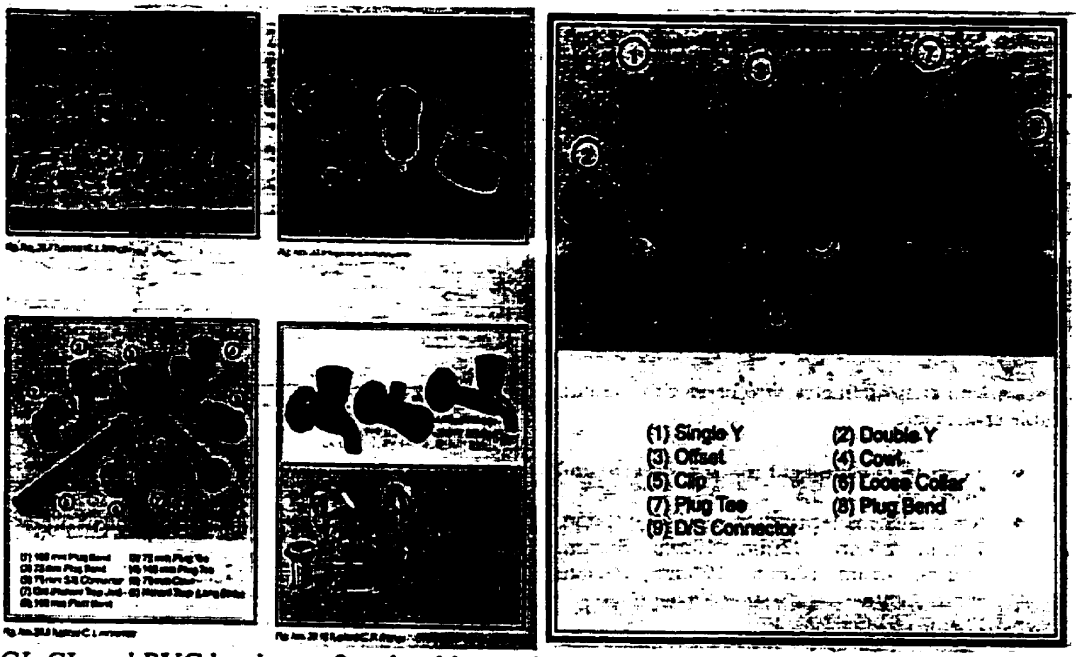
Though piping material has changed, tools for plumbing have not undergone any major change. Plumbers still work with a minimum number of tools like a spanner, a wrench, a plumber's vice, pliers, a hammer, screwdriver and a trowel for civil work. Cement mortar and jute fabric are the common sealants.

A majority of Indian homes do not have hot water supply to all water outlets. Also, there are no room heating systems requiring water supply. Thus piping of homes is limited to basic water supply to toilets and kitchen sink. In many low cost houses and especially in most informal settlements, there is only one water outlet per house or even that could be shared. Piping is thus not a complex job. Piping though is a job that fails if not done properly. Leaking pipes, choked drainages, improper ventilation of pipes are common problems. Quality work is rare in this field. Plumbers need to hold a license issued by the municipal authority to be able to make a connection to the municipal line. Consequently, builders employ licensed plumbers for their buildings. Plumbers who do not hold a license either pay another licensed plumber to sign for them for the municipal

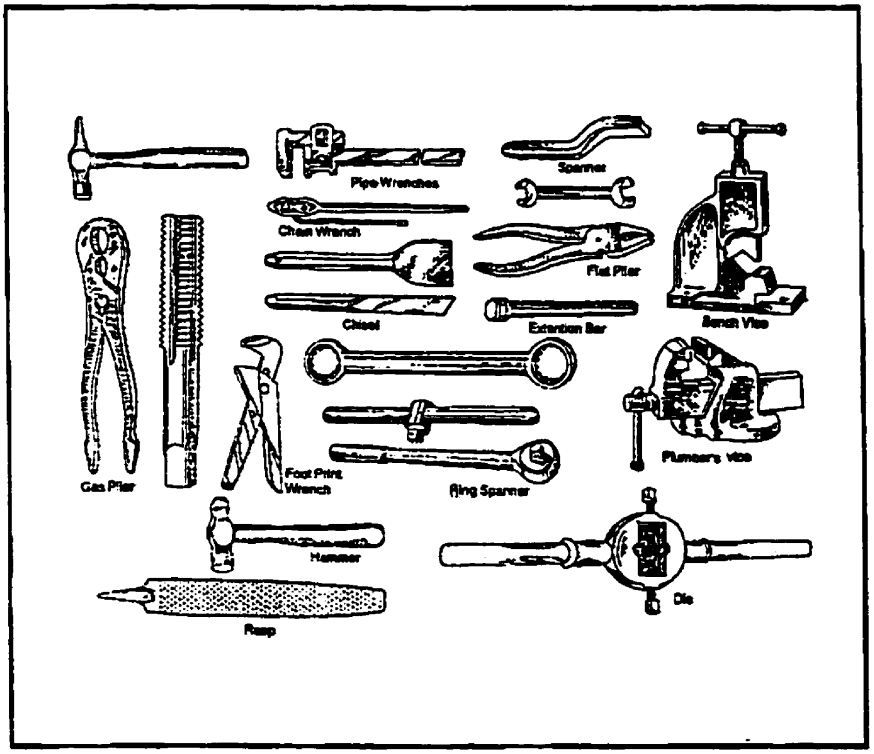
permissions for their clients or do not take up jobs involving municipal connections. Licenses are granted to plumbers after passing a written and a practical test conducted by the municipal authority. Thus licensed plumbers have to be literate. There are no specific training requirements for getting the license as long as the plumber demonstrates adequate skills of the trade. Plumbers who are informally trained on sites under other plumbers pass the test too. The industrial training institutes also teach a plumbing course[64], but plumbers in practice have a similar opinion about these plumbers as fabricators have about ITI trained fabricators.

Plumbers' fees are item based. Helpers are paid daily wages.

[64] These plumbers too have to appear for the license test.



GI, CI, and PVC hardware for plumbing and common sanitary ware



Tools Used by plumbers

Chapter 4: Classified Data, Observations and Inferences

As per the methodology stated in Chapter 1, a sample of 30 workers was studied in depth for the concerned aspects of this research. The following chapter analyses some findings and records observations from the sample study and makes inferences based on them. A part of the analysis and recording of observations is done and presented in a tabular form for quick reference to support the inferences drawn. For the clarity of communication with and the ease of comprehension to the reader, the analysis is presented under various heads that are the broad aspects of workers' systems aimed to be studied in this research.

4.1 Sample profile:

Following are the characteristics in brief of the 30 sample workers. These represent the variables identified of worker types.

Concreting:

Worker 1:Trained in a specialized technique under the guidance of an engineer for a prolonged period (21 years).

Worker 2: New entrant into the construction field. Learning and practicing a new technique.[65]

Worker 3: RCC carpenter for a long period (15 years) under the same builder. Typical case of graduation to a skilled worker from an unskilled worker. Some experience with alternative techniques.

Worker 4: Concreting skills only. New entrant in the field; job hopper.

[65] 'New technique/ technology' refers to technology that is not conventionally used in the field. It may be old in terms of no. of years that it has been known, except being a traditional technology. 'New' does not refer to its newness to the worker.

Worker 5: Local concrete worker doing small jobs. Currently learning new technique under a contractor.

Masonry:

Worker 6: Young mason from a mason family. Experience of specialized and general work.
Worker 7: No experience in masonry. Learning new technology under contractor. Previously done many other non-construction jobs and also some ferrocement work.
Worker 8: Typical case of conventional non- traditional mason. Consistent work with a single contractor.

Worker 9: Free-lance mason. Taking up house construction jobs.
Worker 10: Traditional stone mason with a team of stone masons working under him.

Carpentry:

Worker 11: Traditional carpenter from Rajasthan knowing and using most of the new skills and materials. Team leader. Worked under leading architects for interior jobs.

Worker 12: Recent acquisition of trade skills. Non-traditional worker working under traditional team leader.

Worker 13: Traditional carpenter from Maharashtra engaged in medium scale jobs often not architect designed or supervised. Leader of a small team.

Worker 14: New entrant, traditional carpenter and ironsmith from Rajasthan, emerging team leader

Worker 15: Local carpenter, worked on various jobs and now manufactures furniture at his own workshop.

Fabricators:

Worker 16: Practicing the trade for a long time (14 years). Independent job work, seldom under architects. Collaborator in design and manufacture of construction tools.

Worker 17: Major job work for builders. Doing typical jobs and having a typical establishment.

Worker 18: Working under a non-working contractor[66]. Industrially trained and working independently in spare time.

Worker 19: Local fabricator working on specialized jobs for various architects and builders, has a well equipped workshop

Worker 20: Newly trained fabricator doing any job and trying to establish in the market

Flooring:

Worker 21: Traditional Rajasthani craftsman, team leader, large variety of work under leading architects

Worker 22: Specialized in tile work, work under many architects

Worker 23: Local non-traditional flooring worker employed under contractor

Worker 24: Painter from Uttar Pradesh trained under other skilled workers in Mumbai. Team member of a large team of painters with jobs in cities other than Pune too.

Worker 25: Team leader of large team of painters, family involved in the same trade, work under leading architects

Electricians and Plumbers:

Worker 26: Electrician from a family of electricians, shop owner, medium size wiring contracts and repair work.

Worker 27: Part time electrician, employed with the telecom department, work under electrical contractor

[66] 'Non-working contractor' is a person who does not have skills for the trade but forms a team of workers of a particular trade and takes up jobs. He is the team leader, and employer of all workers under him. In some cases, he may have the trade skills, but may have stopped working himself. In either case, he does not do any kind of skilled work on site.

Worker 28: Electrical contractor, Diploma holder

Worker 29: Local licensed plumber, trained on site. Doing most jobs for builders.

Worker 30: Local unlicensed plumber working for a long period (20 years), doing a variety of both petty and big jobs.

4.2 Analysis of data and recording of observations:

The following is an analysis of data gathered from the conversations with workers. Different tables represent different aspects of the scenario of technology and innovation transfer at the workers' level. A brief note on most of the classification categories is added below each table. It explains the scope and meaning of each of the categories and its significance. Some classifications are such that a worker may be represented more than one time in the table (e.g. table for 'source of innovation'). So the sum total of numbers in all the categories of the table may exceed the number of sample workers (30). It should be noted here that such tables do not represent the number of workers prescribing to the respective categories but are number of possibilities or number of occurrences of that particular category in the total sample. Major heads under which the following classification is made are: personal and family background, training, understanding, choice of and entry into the profession, work team, nature of employment and source and use and dissipation of innovation.

4.3 Personal and family background:

Table 1:

	Local	Migrant	Educated	Uneducated
Concreting	1	4	3	2
Masonry	1	4	1	4
Carpentry	1	4	2	3
Fabrication	2	3	1	4
Flooring/painting	1	4	2	3
Plumbing/electrification	3	2	3	2
Total	9 (30%)	21 (70%)	12 (40%)	18 (60%)

Notes: A 'local' worker is a worker who originates from the region of the study while a 'migrant' worker is any worker who has come to this region in search of employment or otherwise, irrespective of his qualifications at the time of migration.
'Educated' workers are those who have passed at least the seventh grade of school. All others are uneducated. Those listed under uneducated though may be literate to a limited extent (can only read numbers or can read but not write, etc.) but literacy is not necessarily a result of formal education.

Table 1.1: State wise immigrants

Native place	Pune region	Maharashtra	Andhra Pradesh	Karnataka	Rajasthan	Uttar Pradesh	Other
Concreting	1		1	2			1
Masonry	1	3	1				
Carpentry	1	1			3		
Fabrication	2	1		2			
Flooring/ painting	1				2	2	
Plumbing/electrification	3	1				1	
Total	9 (30%)	6 (20%)	2 (7%)	4 (13%)	5 (17%)	3 (10%)	1 (3%)

Observations and Inferences:

A large number of workers are migrants from regions around the study area. These could be regions in the same state of Maharashtra or also from other states like Andhra Pradesh, Karnataka, Uttar Pradesh, Rajasthan, Orissa and Bihar. Such a large population of immigrant workers can be attributed to several factors. First is the availability of ample jobs. The city and its metropolitan area is a developing region and there is a lot of

construction activity going on. Farmers and other laborers from undeveloped and poorer regions of the country migrate to cities in search of employment. In the event of a lull in construction jobs for a certain period, when the job market is down, most of the immigrant workers go back to their respective villages and town where they may have agricultural land.[67] At the onset of an upward swing in the market, they may return to their construction jobs again. The other factor contributing to the immigration is the relative ease of finding a construction job. Compared to other jobs in the industrial sector or even jobs in the other organized sectors, finding a job on a construction site is easier. The job may be of an unskilled laborer but that is no deterrent for a person who has no means of income and in a situation where finding work is the greatest problem. No job of a construction worker demands basic minimum education. Only for specific jobs is a building skill required at the onset of the job. Skills could be acquired later if needed.[68] Traditional construction workers move to cities in search of more work and better earning. They have the advantage of starting at a higher level of job than the unskilled migrants and generally believe in their superiority of skill than the new learner. Traditionality should not be mistaken with conservatism. In fact, traditional workers are seen using the latest tools and techniques. For them, being traditional workers means being the best among all- especially better than new learners and also possessing extra knowledge of their ancestors.

Since most workers are migrants from desperate situations, very few have undergone any formal education. Most of the uneducated have never attended school or have left it in a

[67] It should be mentioned here that most of the migrants are from areas experiencing draughts or very poor areas, both of which render subsistence on agriculture inadequate. This though is not the only reason to migrate to cities. Skilled workers like carpenters from Rajasthan migrate more in search of better exposure and returns for their skills rather than the need to survive poverty in the native villages.

couple of years. The educated workers too have rarely passed anything beyond the tenth grade. Poverty, large family size (number of kids in the family), lack of awareness of and resources for education, and use of children for income generating or other work instead of educating them are the major factors responsible for the large percentage of uneducated workers. The workers who are educated are generally from urban areas where facilities and awareness of education are more. Electricians and plumbers show the highest literacy. This may be because of local youth taking up these professions rather than migrant laborers. To obtain a plumber's license, plumbers need to pass a written test. Thus all licensed plumbers are literate (and usually also formally educated). Many workers express the resentment over their lack of education. Some feel that better education helps seek better jobs since education refines the personality and language and thereby the credibility of the worker in the client's (builders included) view. Learning skills though is least hampered due to lack of education in the present situation.

4.4: Professional training:

Table 2

	Self taught	Informally instructed	Formal training	Traditional training
Concreting	1	3	1	
Masonry	1	3		1
Carpentry		2		3
Fabrication	2	3		
Flooring/painting		3		2
Plumbing/electrification		4	1	
Total	4 (13%)	18 (60%)	2 (7%)	6 (20%)

[68] In fact, table 2 shows that most of the skilled workers start as unskilled workers and gradually acquire the necessary skills to become a mistry.

Note: The above categories mean the following:

Self taught: Learnt skill by observing others work, or voluntarily asking questions and learning from a mistry, architect, engineer, supervisor, contractor or any other person knowing the skill. Most of the learning in this method is by trial and error and sometimes the whole process might be kept secret especially from the mistry. The skill is practiced with petty tasks assigned by any of the above.
Informally instructed: A mistry (or sometimes an architect or engineer) may instruct his unskilled or semi-skilled helper and train him to do petty jobs under his guidance or in his absence. This may be done by the mistry for various reasons- building up a team (carpenters), training an apprentice (mason), or executing a special/ non-conventional job (architect/ engineer). The semi-skilled/unskilled worker thus gets training and practice on the work sites and gradually masters the skill to become a skilled worker. Opportunities arise from time to time for him to start working as a skilled worker. The most usual of these are: need of more workers by the contractor under which the worker is working; original skilled worker leaves the job or is unavailable; there are job opportunities in the market where the new worker can take up work independently.
Formal training: A worker may be trained in a vocational institute like the ITI (refer to note on training institutes in chapter 5). Workers systematically trained by an architect/ engineer in a specific specialized skill with the aim of creating a skilled work force (ferrocement) too are included in this category.

Observations and Inferences:
Informal instruction is the most common form of training. Self-learning is the second option. The source of informal training could be an architect or a mistry while self-learning entirely is by observing the mistry work. The mistry is not always willing to teach except in some trades (carpentry). The unwillingness of mistrys to teach may emerge form the fear of creating competition or losing the power of being the exclusive holder of a skill over unskilled subordinates.[69]

[69] Worker 2 worked as an unskilled worker under his uncle who was a skilled ferrocement worker. The uncle avoided teaching this apprentice to the extent that he would not even let worker 2 see special skills being used by him. He used to secretly cut the mesh so as not to let his apprentice know how the task is done. Worker 2 would take pieces of mesh home and try to cut it in different ways till finally he discovered the right technique through his trial and error method.

Observation and trial and error whenever possible are the learning methods.[70] It usually does not take more than a few months to learn most of the trades, but a few may take longer. Learning alone though does not suffice. The skill has to be practiced and perfected. For trades that have a traditional predecessor, workers who have learnt the craft in one form or the other could be found (e.g. carpenters with skills of working with solid wood rather than plywood; stone masons rather than brick masons). They are generally believed to be superior in their work and have more working skills than new learners have. Workers opine that the only prerequisites for learning a skill are willingness and sincerity of the learner and that it shouldn't take long to learn any skill. But many workers find apprentices under them lacking the capacity to understand the work and the willingness to work hard to obtain the skill.[71] Carpentry some how shows more traditional workers than new entrants. This could be attributed to the fact that carpentry is a craft oriented job and requires more skill and practice, and hence more time to learn than most other jobs. Also, all carpenters in the sample who were team leaders clearly indicated a tendency to include only family members in their teams (Table 4). Formal training in the form of short-term courses in training institutes is available. 102 industrial training institutes (ITI) in the state of Maharashtra alone run one year courses for 10 trades and two year courses for 49 trades. Of these, courses for building constructor, carpentry, welding, plumbing, electrician and painter are relevant to the home building industry. Table 7 in the appendix shows that there is full capacity

[70] Traditional Rajasthani carpenters however reported of a systematic learning process for the apprentices. Introduction to various tools and materials, simple skills like fixing and unfixing nails and screws, sawing the wood and then cutting it is the sequence followed. But the teaching method is informal and through practical on site work.

[71] An engineer who has been training workers for many years in the use of ferrocement observed that it was easier to teach unskilled workers than workers with any previous skills since the latter had preconceived

utilization with a success rate of 70% in all these institutes. Apart from the I.T.Is, a handful of large construction companies (nearly all based in Mumbai) offer in-service training to their workers. There are also a few non-government institutes running short-term training courses for specific building trades. But despite the presence of all these training facilities, the absence of formally trained workers is evident in the sample.[72] From tables 6 and 7 in the appendix, it can be seen that the number of formally trained workers is far too less than the total number of skilled workers required by the housing sector. Also, a majority of the skills are useful in other industrial sectors too and naturally, trained workers opt for jobs in other industries. These industries too prefer formally trained workers to untrained labor. A minimum education till the tenth grade of school is the eligibility criteria for all the I.T.Is. Table 1 shows that 60% workers are uneducated while out of the 40% educated, many may not have studied till the tenth grade. This rules out training at the I.T.Is for most of the worker class. Also, a formal training is not mandatory while joining the profession. For most workers, the usual way to train themselves is seeking employment under a skilled worker and work as his apprentice.

Architects and engineers may occasionally train workers for specific jobs as exemplified in the case of concreting where all the ferrocement workers are architect/ engineer trained. The architect/ engineer may regularly engage these workers for that specific skill. Workers in all other trades have denied learning anything from the architects/ engineers

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ideas about the way things are and should be done and are find it hard to accept alternative techniques and building components.

[72] Electricians mentioned some ITI trained workers currently or previously employed with them. A general comment was that these workers demand a much higher salary than other workers on account of their training. Job wise, it was felt that though they knew the theory well, skill wise they were at the same level as untrained workers and had to be trained as any other new worker. This is the observation of the sample workers and is not verified for its validity.

except for good design ideas. Most workers, except carpenters, have not met architects on site nor have received any guidance from them regarding work skills.

Time is an important factor involved in teaching and learning of skills. The work schedule and the nature of work provide little opportunity and time for proper training on site. No worker can spend his work hours teaching or learning. The only time to teach and learn is the small breaks that the workers have twice or thrice a day. It is entirely up to the wish of the learner to learn any skill. Many are satisfied doing their unskilled or semi-skilled jobs. For the ones wanting to learn, there are hardly any sources available other than the mistry on site, whatever his expertise. Especially on the sites of builders, there is hardly any chance of an architect/ engineer training workers.[73] Even in case of the use of an innovation on such a site, the implementation procedure is explained to the supervisor who in turn gets the task done from the workers.

Most part of technology transfer to workers is learning and mastering of manual skills. Skills require practice and practice requires both, time and practicing opportunities. Abstract concepts, to a limited extent, also form a part of complete technology transfer to the workers. Comprehension of these may be lacking in workers due to various reasons. Heavy manual labor may be too tiring to leave the patience and energy to think; many workers are uneducated while many do not see the point in learning new things. As long as they get their regular pay, they are satisfied. Also, while skills are picked up fast-whether informally taught or observed or experimented, conceptual transfer is very slow and low, as concepts cannot be imbibed fully by these methods. It is also doubtful whether even skills could be properly learnt by such trial and error methods in the

[73] All workers replied in the negative when asked about the presence of architects on builders' sites.

process of self-learning. Such a process of learning amounts to stagnation of skills, rather than improvisation and development with successive users.

4.5 Comprehension and allied skills:

Table 3:

	Conceptual understanding	Only skill	Part concept	Understanding measurement	Estimation of quantities and cost	Bill preparation	Drawing comprehension
Concreting		2	3	5	2	5	3
Masonry		1	4	5	3	3	2
Carpentry	1	1	3	5	5	4	4
Fabrication		3	2	5	3	3	3
Flooring/painting	1	1	3	5	4	5	3
Plumbing/electrification	2		3	5	4	4	3
Total	4 (13%)	8 (27%)	18 (60%)	30 (100%)	21 (70%)	24 (80%)	18 (64%)

Note: The above categories mean the following:

Conceptual Understanding: Conceptual understanding refers to the basic understanding of the logic or science behind a certain technology or technique. The scope and definition of conceptual understanding would differ for different technologies. A brief list of 'indicators' used to judge the understanding of a technology is as follows:

Concreting: i) concept of composite material and the role of each constituent ii) load transfer system iii) role of main and distribution steel iv) types and methods of spanning v) cover vi) different mixes of concrete, their properties and applications vii) water-cement ratio viii) curing ix) defects in concrete work, its causes and corrective methods.

Masonry: i) quality and strength of bricks, stone or other masonry blocks ii) different mixes of mortars and their applications iii) relation of thickness to load to be carried and relation of length of wall and its thickness iv) spanning capacities and methods, arch action v) joints vi) plastering/ other finishing and its requirements

Carpentry: i) properties and applications of different boards; types, properties and applications of wood iii) various types, properties and applications of joinery iv) defects in wood and board work and its causes and corrective measures v) effect of moisture on wood and board work. vi) types of adhesives and their applications vii) finishing and other treatments for wood and board work.

Fabrication: i) properties of different materials- solid and hollow sections and their applications ii) strength and weakness of welded joints, riveting iii) spanning and load bearing capacity of mild steel; trusses iv) decay and maintenance of steel v) general differences between mild steel and other steels vi) current and power requirements for welding vii) electric charge and generation of electric spark for welding; earthing

Flooring: i) properties and application of different natural stones and artificial tiles ii) different types of sub floor bases and bases for dado iii) joinery for various types of materials; insitu floorings iv) defects in the flooring/ dado material and desired sizes and thickness v) finishing requirements and maintenance

Painting: i) various kinds of paints, their properties and applications ii) characteristics of a good paint iii) basic information about the properties and applications of various bases and thinners iv) process of painting walls, woodwork and metal work vi) Use of various brushes and sprays vii) defects in painting and their corrective procedures viii) special paints and their applications

Electrification: i) charge- positive and negative, earthing, current, sparking ii) measurement of charge, voltage, current iii) accidents and safety measures; fuse iv) power requirements for various appliances v) distribution systems, loops, circuits vi) role and working of devices like transformers, adaptors, stabilizers

Plumbing: i) properties and applications of various types of pipes ii) desired diameters and slopes for various applications iii) sanitary requirements for laying water and sewage pipes iv) ventilation requirements and systems for ducting v) various traps, cocks and other devices and their applications vi) hot water ducting requirements vii) design and working of septic tanks and water storage tanks ('design' does not refer to structural design) viii) wear and tear of pipes and their maintenance and repair.

Understanding of all the above listed aspects of a certain technology correctly, entitles a worker to be listed under 'conceptual understanding'; if a worker knows half the number of total aspects or more, he is listed under 'part concept' and if his knowledge is below half the listing, he is listed under 'only skill'.

Observations and Inferences:

Conceptual understanding is the lowest. Its small presence in workers practicing carpentry, and flooring is because of the relative simplicity of the concepts involved and in electrification because of practical experience and education needed to practice the trade. Concreting technology and masonry are difficult techniques to grasp conceptually

and require a minimum amount of engineering skills. Thus, no sample shows a complete understanding of these two trades, though the percentage of workers partly grasping the technology is high.

If education is any indicator of grasping and comprehension capacity, it may be assumed that for most workers, it is difficult to comprehend any technology in its totality because of the lack of basic education. In such a case, it is too much of an effort to understand and learn a new thing unless it is essential for survival. Also, because of the tight and heavy work routine and the risk of deviating from it, few would venture to undertake such a task upon themselves. Only that part of the technology, apart from the manual skill, that is self-evident and self-explanatory in its implementation process is transferred to the workers.[74]

A question could be asked regarding the relationship between basic education and aspects of any technology that need to be understood by workers. It is evident that information that is necessarily transferred through reading and writing would not reach most workers (most concreting workers cannot read the date of expiry printed on cement bags). Workers however have a better grasp and understanding of tools and techniques for any job execution. They can and do formulate thumb rules for the techniques they practice and can manipulate the technique as per site conditions and requirements. There are many examples[75] in the sample where workers have ingeniously solved practical difficulties on site or even developed a technique to execute a particular job (refer table 12). It wouldn't

[74] E.g. optimum spans of RCC beams, use of patli in brick masonry, strength of a hollow mild steel pipe, function of an electric fuse.

[75] Some examples are: worker 3 devised a method to lift precast roof panels, worker 6 made a tool to ensure uniformity of the height of brick courses in an exposed brickwork, worker16 made a coloring trough for fast completion of a painting job.

be farfetched to expect an active collaboration between architects/engineers and workers to develop new and efficient ways of planning and building houses.[76]

Workers show a good understanding of skills supplementary to their job skill. All workers understand measurements- most of them in both millimeters and inches. A majority of them also know how to bill the client for their work. This implies their skill in quantifying their work. The skill of estimating material required for a particular job is more seen present in carpenters since in most jobs they are given the responsibility to work out the quantities.[77] Understanding drawings too is a tricky skill to judge. Architects and contractors have reported drawings being misread and misunderstood by workers (and even site supervisors) on a number of occasions. Many a times, drawings are not given directly to workers but to supervisors (or the site in-charge) who in turn explains them to the workers. Even in cases where drawings are handed to workers, they are explained orally too. Workers have often mentioned absence of any drawings.[78]

Wherever there is an interaction between the worker and the architect (carpenters), rough sketches and oral instructions are the most common means of communication used. It cannot be judged whether workers understand drawings in a general way. But as worker 7 explained "I can understand the drawing drawn by him (contractor) as it is related to the actual work I am doing here".

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[76] Worker 1 reported of constant experimentation on his part along with that of his engineer employer and trainer to further develop the technique of using ferrocement.

[77] Though most workers claim that they can make estimates, architects and contractors opine that most of the times these are wrong. Carpenters are usually an exception and even most architects and contractors leave the job of estimation to carpenters.

[78] Fabricators never mention getting drawings for doors and windows. They usually do the items on their own as per standard design. Designs for grills are taken from design books. Most of the gate and fence designs too are done by fabricators themselves from books or by looking at other executed designs in their surroundings.

4.6 Work team:

Table 4:

	Lead team	Family/ kin as a part of the team	Proactively train subordinates
Concreting	2	3	1
Masonry	1	1	1
Carpentry	4	3	3
Fabrication	3	2	3
Flooring/painting	3	3	4
Plumbing/electrification	4	1	3
Total	17 (57%)	13 (43%)	15 (50%)

Note: A worker who is the leader of a team of skilled/ unskilled workers is included under 'lead team'. Virtually in all cases the team leader is also responsible for forming the team. If the team is not permanently employed with an agency (contractor/ supervisor etc.) the responsibility of finding work for the team rests with the leader. The leader should also understand the job well and explain it to his team members. In case of absence of a supervisor or contractor, a team leader is the main link between the designer (architect/ engineer/ client) and his team members. He should be in a position to understand the intended work and communicate it to his team for its proper execution.
'Family as a part of the team' refers to inclusion of family members in the working team as skilled workers or apprentices as typically seen in traditional family professions like carpentry where father and sons and even uncles and distant relations work together as a team. This does not rule out the inclusion of non-family members in the team.
Team members may be already trained in the needed skills before joining the team. If not, some team leaders will train them once they are a part of the team. It is not necessary for the team leader to personally instruct the apprentice; he can assign the task to the other skilled members of his team. Such team leaders whose teams provide for such a kind of training are listed under 'proactively train subordinates'.
Observations and Inferences:
More than half the number of sample workers are team leaders. Trades like carpentry and concreting may require more teamwork than others; but single mistrys for both these trades could be found too. Team members are a mix of skilled, semi-skilled and unskilled workers depending on the trade and the scale of jobs that the team handles. Carpenters would require skilled workers while a concreting team may require more unskilled workers. This also reflects in the training given to team members. Carpenters actively

train new entrants to produce skilled workers to work in the team whereas a RCC mistry who needs no help from any skilled worker would be hesitant to train anybody in his job for the fear of creating competition.

More than half the number of team leaders show a preference to employ family members in the team. This preference is more pronounced in teams of traditional workers and especially carpenters. This preference is based on the wish to avoid conflicts, ensure continuous work, reduce the outflow of trained workers, and also to help the family economically. Teams of concrete workers are composed of people from the same region or tribe (Wadaris) if not related. A team of workers from different regions is very rare unless formed by a contractor or other employer. Electrification and plumbing trades do not show a big team building nor do teams show any significant presence family members.

Workers who are not team leaders may be employed under a contractor or in a team under another mistry. Masonry is a skill that can be practiced individually with the help of two more unskilled workers and hence masons rarely have a team per se of their own.

4.7 Entry into and choice of profession:

Table 5:

	First profession	Started work as unskilled worker in construction field	Hopping from other construction professions	One of the many non - construction professions	Tenure in the current profession	
					0-5yrs	5-15 yrs
Concreting	4	4		1	1	4
Masonry	3	4	1	1	1	4
Carpentry	4	1	1		1	4
Fabrication	3	3	1	1	0	5
Flooring/painting	3	4		2	1	4
Plumbing/electrification	4	4		1	2	3

Total	21 (70%)	20 (67%)	3 (10%)	6 (20%)	6 (20%)	24 (80%)

Note: First profession refers to a case when the profession that the worker is practicing now is his first profession i.e. he has not been doing any other job/ practicing any other profession before the current profession, irrespective of it being a construction or non-construction profession.

Workers may start working in any construction trade as unskilled or semi-skilled laborers and gradually acquire some skill to become skilled workers. In the process they may change the trade they began working in (a bar bender for RCC work may become a fabricator). Such workers are included in 'hopping from one trade to another'. Workers who do not change trade in the process but become skilled workers in the same trade in which they were unskilled workers are included in 'first profession'. Workers who have hopped to the present trade from some trades outside the construction industry are separately included under 'One of the many non -construction professions'. Most of the times for these workers, securing any job is the first priority and their entry in the building industry is a quest for the same. Although they are classified separately in the above table, a general remark about their tenure in the construction profession or their interest in it cannot be made. Any such remark may be true for other workers too and not a necessary characteristic of such workers only.

Observations and Inferences:

Immigration of workers to the cities, skilled or unskilled, usually shows a typical pattern. Mostly, somebody from the family- either an elder brother or an uncle- come to the city and find employment. When they are fairly settled, they invite one of their relatives to join them in the work they are doing or may help him find another job. Immigrant relatives of construction workers usually join the construction field. They may work in the same trade or may change the trade depending on the availability of jobs. Traditional workers would try and retain their profession even after migrating. Most of the non-traditional workers enter this field as unskilled workers. Many a times, a job similar to that of his host relative is obtained. If the host has a team of his own, the new entrant joins the team. Thus there is little choice and selection possible for entrants in this field. A worker may later change the trade because of later opportunities to learn a skill while working under another mistry. A bar bender becoming a fabricator (worker 16) or a site laborer becoming a mason (worker 8) are examples of this. But despite the lack of initial

choice, the table above shows that workers in this field are quite stable. They remain in the field for a considerably long period of time.[79] This is an asset to the industry in many ways- especially for training of and investing on the workers. This long stay in the field may be a result of the long time required to make progress in the hierarchy of workers or the low risk- stable earning[80] nature of employment or the potential of future self-progress as seen by the workers in this field[81]. It could also be that there are no easy opportunities outside this field. In case of skilled workers, acquiring skills and establishing oneself as a skilled worker takes a considerable amount of time.[82] Once a skilled worker, work is adequate if not in excess. At such a stage, one would not venture out to seek a job in a new field of which one has no skills.

[79] Workers may move within the construction field from one contractor to another but they seldom change their trade.

[80] Earnings are low compared to industrial workers and employment is without any benefits of a legally recognized employee. But given the qualifications of the workers and the difficulty in getting a better job outside, the earnings in this job are satisfactory.

[81] Future development as visualized by many workers (concrete workers and masons) is becoming a contractor or a builder.

[82] For an unskilled worker, getting an opportunity to learn a skill itself is a time consuming process. Workers have reported the time taken for learning a skill from a few months (for simpler skills like basic electrification, a few plumbing skills) to a few years (for any complete skills of a trade and difficult skills like masonry and plastering, carpentry). In addition to this is the time required to get work to practice and

4.8 Employment:
Table 6:

	Permanent employment	Free lance
Concreting	1	4
Masonry	2	3
Carpentry	1	4
Fabrication	2	3
Flooring/painting	1	4
Plumbing/electrification	1	4
Total	8 (27%)	22 (73%)

Note: Permanent employment does not necessarily mean a formal and legal employment. Many a times, workers may permanently work under one contractor or supervisor but are not legally listed as employees. Thus they may not be entitled to salaries if there is no work with the contractor for a certain period. Also they do not have any other benefits of legal employees such as provident fund, insurance etc. The term 'permanent employment' refers loosely to all workers who work under a single contractor/ supervisor or other agency for a very long duration of time and on various projects and virtually permanent employees of the same. These workers may occasionally take up work on their own when their employer does not have work for them. But they will always return to their employer once it is over.
Workers who find their own work and generally not under a single contractor/ agency are termed as freelance workers. They seek work on a contract basis and are involved with the employing agency (this may be a client) only till the completion of the contract. Informal groups/ teams of such freelancers and architects/ contractors may be formed and they may generally work together on most projects. But there are no legal obligations and the relationship is not of an employer-employee type. Each worker is identified, termed and treated as an independent agency.
Observations and Inferences:

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master those skills. Thus on an average, a minimum of 2-3 years are required for a any worker to become a fully skilled worker after the beginning of his training.

There is hardly any permanent employment for construction workers. The small percentage of permanent employment seen in the sample is only virtually permanent. These are examples of workers continuously engaged by a single agency, may be a contractor, builder, mistry or architect/ engineer. But they are not legal employees. There is never a job security and hence any economic security for the construction workers. Those not employed and working freelance are not sure of regular work either. In such a condition finding and securing work gets priority than the actual work itself.[83]The whole thrust and focus of life is to earn and keep finding work for bare minimum support. This completely rules out the possibility of taking risks- financial, reputation or otherwise- inherent in the use of innovations. Any loss has a big impact for their daily lives and it may take a long time for them to recover from it.

Employed workers may also find independent work. Use of innovation is possible in such a case where the workers have thoroughly learnt the use of that particular innovation under their employer and as freelance workers have the choice of technology.[84]

For a worker trained in a specialty skill/use of a particular innovation (e.g. ferrocement-worker 1) ample work may be available because of scarcity of workers of that particular type but in some cases he may also find it hard to get work unless he knows some other

[83] This also means spending minimum amount of time on a job not paying daily wages (team leader pays daily wages to his team members while he himself is paid on a lump sum/ percentage or item basis as explained in chapter 3). This means finding ways for hasty completion of jobs to move on to new ones. Therefore the reluctance to spend time on details of techniques to ensure quality.

[84] A painter working independently may have the choice of technique- brush or roller finish- to be used in his work and he would opt for the one that he is most conversant with. Similarly, carpenters working independently would decide on the material to be used for a particular job. This freedom of choice of technique is most possible when workers are not employed under a contractor or are not supervised by architects in which case the latter make the technology choice. In most of the jobs taken up independently by workers, the choice of technology largely depends on the workers' expertise and thee client's budget.

skill[85]. Thus use of some innovations would also depend on their demand in the market and the employment they generate thereby.

New entrants into this field rarely have the choice of the trade that they work in. They usually continue to work and learn in the trade in which they first get a stable job. So the aspect of aptitude and interest in a particular trade becomes irrelevant. As the trade is not opted for by choice, there may not be specific aspirations or goals regarding work and progress in that particular profession. Once in the trade, most goals are economic and financial profit and quality work are not related.

Most workers are dependent on the contractors, builders, architects or mistrys for employment. Employment is never guaranteed and never steady. In such a condition, work is mostly prescribed by the employing agency and there is little scope for a worker to exercise his choice of material or technique.

[85] Worker 6 skilled in doing exposed brickwork has never done a project using exposed brickwork ever since the one he learnt the skill on. To keep himself employed he has to accept regular 6" brick masonry jobs on sites of various builders.

4.9 Source of innovation:

Table 7:

	Construction professional	Suppliers, other market agents and media	Construction sites/ finished projects
Concreting	4		1
Masonry	3	1	1
Carpentry	2	4	3
Fabrication	1	3	
Flooring/painting	2	4	2
Plumbing/electrification	1	4	
Total	13 (43%)	16 (53%)	7 (23%)

Note: 'Construction professionals' include architects, engineers, contractors, supervisors or even colleagues (A transfer from a colleague was not encountered in the study sample except in the case of a traditional Rajasthani carpenter. The transfer from a skilled worker to an apprentice is more common than a transfer to a colleague).
'Suppliers and other market agents' include building material and tools suppliers, marketing agents of product manufacturing companies, and print and other media publicity. Government publications, brochures by different research institutes, and related propaganda are not included in this category. Also these publications were not cited by any of the sample workers as a source of innovation.

Construction sites and finished projects may act as sources of innovation for some workers. Workers may come to know of certain innovations from these sites or may even observe and make inquiries about how a particular job is being done on the site. Such cases are listed under 'Construction sites/ finished projects'.

Observations and Inferences:
Construction professionals and the market- media are the biggest sources of innovations. Trades like concreting and masonry show a dominance of construction professionals as their source of innovation while the electrification and plumbing trades have the market as their major source. Both, concreting and masonry, are technique oriented trades-

material innovations in both are not very common (except for various grades and brands of cement). Both these technologies use basic raw materials[86] and innovations are done for the technique of using these materials (e.g. ferrocement and RCC; various bonds for bricks etc.). Since the major innovations are pertaining to technique, and any industry being unlikely to market a technique, such an innovation is only dissipated by construction professionals. Conversely, the market is more replete with product innovations and more aggressive in its dissipation efforts. As a result, trades like electrification and plumbing, which use most of these product innovations, show the dominance of the market as their innovation source. Carpentry, which has both, innovations in material and technique, accordingly shows an equal reliance on both sources for its innovations.

The most frequent construction professional to be an innovation source is the contractor. Architects and engineers are sources only to those who are virtually employed under them i.e. are a part of the architect's/ engineer's regular work team for most projects. Same is the case with contractors. Consequently, freelance workers heavily depend on market sources of innovations. Of the market sources, suppliers are a major source of information on new products.

Suppliers even introduce new machines to the workers and explain how to use them. It could be deduced that the tools introduced in the market ought to be simple to understand since explanation by a stockist is enough for the worker to use it or that the workers should have a basic idea of the general working (operation) of any tool, and they are ready to take the risk of using new tools recommended by the supplier.

[86] Brick could be called a product; but it is still a very basic product manufactured by local brick makers out of local clay, unlike other products which are industrially manufactured.

4.10 Acquisition and use of innovations:

Table 8:

	Voluntary search for innovations/ new technology	Passive recipients of innovations/ new technology	Voluntary use of new technology /innovations
Concreting		5	3
Masonry	1	4	1
Carpentry	2	3	2
Fabrication	1	4	1
Flooring/painting	1	4	1
Plumbing/electrification	3	2	2
Total	8 (27%)	22 (73%)	10 (33%)

Note: Workers may receive new technology (in any measure- from general information to implementation technique) either passively or after an active search. Though the sources for new technology in both cases might be the same, the role of the worker in acquiring the technology from the source is different. This classification assumes importance in gauging the initiative and awareness of the worker class as also its potential capacity to act as active technology dissipaters and developers. The last column, listing workers voluntarily using new technology indicates that workers who have not actively sought new technology may also voluntarily use it. Thus the diffusion process has diffusion agents in both types of workers. And importantly, it is observed that technology diffusion does not necessarily depend on active innovation seekers alone.

Observations and Inferences:
Though various sources as listed above are available to workers to learn about innovations, it is observed that active seeking of innovations is not very common. Most workers receive innovations passively. Workers may use an innovation when they are fairly familiar with it on account of frequent use on other sites. These are the sites that act as training grounds for the workers; these are also the sites where the responsibility of choice of material, technique and its performance rests with somebody else other than the worker (an architect/ engineer/ contractor who is trying out an innovation). But only when an innovation becomes an established market product/ technique, it is used voluntarily by most of the workers.[87] Only a few workers experiment with newly learnt materials and techniques and fewer still promote it.

4.11 Further classification and correlation:

Table 9: Changes experienced by traditional workers

	Technique change	Tool change	Material change
Masonry			1
Carpentry	4	3	3
Flooring	1	2	2

Table 10: Employment and source of innovation

	Employer	Market/ media	Field applications
Working under architect/ engineer	3	2	
Working under contractor	5		3
Working independently		3	2

[87] The process of a new material / technique getting established in the market is complex and depends on numerous factors. This study only looks at workers and finds that they do not play a very significant role in establishing a product or technique.

Table 11: Source of informal training

Architect/engineer	6
Supervisor/ Contractor	3
Mistry	9

Table 12: Nature of self-input of workers

Improvement of technique	2
Modification of tool	4
Better implementation technique	8

Table 13: Education and Comprehension

	Only skill	Part concept	Full technology
Educated	1	8	3
Uneducated	7	10	1

Table 14: Source of innovation

Architect	3
Engineer	2
Contractor/ Supervisor	8
Mistry	3

Chapter 5: Tradewise Discussion

5.1 Concreting:

Concreting by its nature is a laborious job more than a skilled job. Most part of the job involves executing perfunctory tasks for which the understanding of the concept of the technology or even a basic idea of the final product may not be necessary. Thus it is not uncommon to find workers doing a good job but without having a clear understanding even of the basics of RCC technology.[88] These are comparable to human machines. This phenomenon of human workers doing jobs akin to machines in terms of understanding is common to most of the building trades. This could be attributed, again akin to most of the building trades, to the distancing of technology and the actual worker. Particularly in concrete works, this is evident in the total dependence of the worker on the structural designer for building any kind of structure using this technique. The role of the worker is reduced to carrying out instructions of the designer without requiring any mental input. Laying bars of specified lengths and diameters at specified distances, erecting formwork for components of specified dimensions and shapes and later mixing and pouring concrete of specified proportions are all tasks that require little or no thinking or understanding about the technology by the worker. The only input from workers could be practical suggestions for adjustments for easy tying of complex reinforcement, efficient use of available material for shuttering, erection of scaffolding, or any other suggestions for solving practical execution problems on the site. But for the technology to be used in a new place, the worker, despite learning the skill to execute a RCC structure, has to

[88] RCC commonly refers to a column beam type of a frame structural system built using reinforced cement concrete.

revert back to the structural designer for a new design. On this front, the technology can never be fully transferred to the worker. The nature of the technology is such that no standardization has been made for usual applications. The design is site specific and non-replicable as long as the same building is not repeated in a new location. In this respect it is still a craft, but one dependent on an agency other than and in addition to the actual hands on worker.

But despite all the above-mentioned characteristics of the technology, RCC has still diffused far and wide even in the rural areas and surprisingly being used without any assistance from qualified structural designers. Interestingly, this phenomenon too can be attributed to the very characteristics of the technology itself. RCC is a robust technology in terms of design, safety, and performance. A threefold factor of safety assumed in its design makes it virtually failure proof even under conditions of poor quality materials, approximate structural design, and unconsidered loadings. Its non-failure even when approximately designed by non-professionals has encouraged many workers to adopt the technology for their independent projects. With a wide common knowledge base about the technology in the form of thumb rules of sizes of various components, the amount of steel used and the proportions of the concrete mix, it is not very difficult to put it to use without professional assistance. This common knowledge base is a result of experience gained by workers on various sites under engineers or even repeated self-use. RCC is the most frequently used technology by architects and engineers in any kind of projects, especially in the housing sector. As a result, a large number of workers working on these sites get exposed to this technology and get trained to build with it. When given a chance to build independently, it s no wonder that they choose to use the same technology that

they are familiar with. Another factor contributing to the wide diffusion of the technology is the easy availability of the required materials. Also its ability to perform in a wide range of regional variations of climate, topography, etc. is an encouragement for its use. The public perception of RCC and its effect on diffusion has already been discussed in the previous chapter.

5.2 Masonry:

Masonry is the chief construction trade and therefore necessary in virtually every building. It has not undergone significant changes over the years but continues to be practiced as was traditionally done. The change has come about in the workers though. Masonry today is hardly a family trade. No family traditions are seen continuing in the trade except for a few stone workers or other specialty masons. There are many first generation masons trained under other masons, which is the predominant mode of learning masonry. But the reluctance of teaching the skill to a trainee is more pronounced in masons. Masonry is a skill that can be (and in many instances is) practiced by individuals rather than a team. A mason does not need another skilled worker to help him do his job. Thus any person he trains is a potential competitor rather than help; hence the reluctance to teach.

The technique of masonry has not changed much and nor have tools. Introduction of power tools, which is a very common change in other trades, has no applications in this trade. Building materials, generically, are the same. Various blocks (concrete blocks, fly ash bricks) are essentially the same building block in terms of construction technique. Mortar used for all is essentially cement mortar (mixes differ). Innovations of technique

are made by a handful of architects/engineers. These, as said in previous chapters, are slow in their diffusion as they depend on individual efforts rather than market agents for their promotion. Some research institutes and an extremely less number of industries (only one in this region) have developed alternative walling systems using precast panels. While research institutes are ineffective promoters, industrial systems are installed by their own agencies. So these technologies never reach the field masons. The current type of masonry is also more cheaper and easier to build and maintain and flexible in its applications than its alternative counterparts.

Masons are equipped to do a variety o jobs other than building walls. Generally, masons also lay flooring (except specialized floorings where special craftsmanship is needed- marble, granite or ceramic tile floorings), build kitchen platforms, fix doors and windows, and waterproof the roof. Thus, with the help of a few other agencies for roofing, painting etc. a mason can build a complete house by himself. Many masons do take up turnkey jobs of small houses.[89]

With the advent of RCC frame construction, masonry walls are a mere infill. With more and more buildings employing the structural frame system, structural masonry has taken a backseat. Newly trained workers therefore lack experience in this aspect of the job. Mastering the trade requires more practice than understanding. Education does not play any role in the ability of the worker to comprehend and practice the limited technology that he uses the most.

Masonry forms a major part of any building; hence masonry work in a project goes on for a considerable amount of time. This keeps the worker engaged for longer periods

[89] Architects or engineers are not involved in such projects. Similar jobs may be taken up by workers of RCC and masons may be hired. Masons prefer to take jobs not involving RCC work.

compared to workers in other trades, giving him the advantage of a steady employment for longer periods of time. Continuous work at a single site is also conducive for training new workers. Masonry being an independent job rather than teamwork does not provide opportunities or occasions for masons to meet and interact with each other.[90]

5.3 Carpentry:

Carpentry is a unique that has experienced both material and technique innovations. Materials have completely changed from traditional ones and so have techniques to use them. Tools too have changed though most are power replacements of traditional ones rather than completely new introductions. In accordance with this multi-faceted change the sources introducing this change to the workers are varied too. Carpenters receive innovations from the market in a major way but also from architects. A strict distinction cannot be made about what type of innovations are introduced by each of these agencies. Despite the changes carpentry with regards to the operations of workers has only partly changed. The most significant change is organizational. While traditional carpentry was more of a one-man job[91], now a days carpenters are seen forming a team under a team leader who is responsible to find jobs, train apprentices, and provide a more or less steady employment. Due to the nature of the work, which necessitates team formation, transfer of skills is more frequent in this trade. Apprentices are one of the team members and are perceived as essential elements to produce new skilled workers who are continuously needed. Traditional carpenters from Rajasthan also have a custom of meeting with all

[90] Traditional carpenters from Rajasthan have a custom of meeting with all other Rajasthani carpenters on the new moon day. This meeting is used for exchange of information regarding work and other topics. No such practice exists in other trades irrespective of their being traditional or otherwise.
[91] This includes a small team of family members.

other Rajasthani carpenters on the new moon day. This meeting is used for exchange of information regarding work and other topics.

Carpentry, as practiced today, is a relatively easier technology to comprehend than most other technologies. As a result carpenters show a much higher and better level of understanding of both aspects of the technology, viz. concept and technique. The area of expertise seen wanting in carpenters is design. To an extent this need is fulfilled by numerous design books available in the market and popularly used by most carpenters.

5.4 Fabrication:

Fabrication is a trade without a direct traditional predecessor. Yet fabrication has not undergone any significant change since its formative days. The only significant change that has come about is the replacement of gas welding by electrical welding.[92] The other change has come about in tools wherein power tools for cutting and grinding have replaced their manual counterparts. Fabrication still is a technology used to produce standard item from standard materials. No new applications of mild steel (M.S) have been developed for the construction of houses. High costs of steel as compared to other building materials and its poor quality may be deterrents for its wider applications. Whatever the reason, the absence of innovations in applications has resulted in absence of novelty in the skill. Fabricators follow a standard method of learning the trade under another skilled worker while employed under him. The know how of fabricators is more or less same throughout the workers in the trade.

[92] Riveting today is no more a common practice but for the scope of the home building industry riveting was never a major technique used for steel work.

5.5 Flooring and painting:

Flooring and painting are finishing items. The finesse and accuracy in both is therefore important. Craftsmanship and perfection of skills is therefore valued in both the trades. Since skills involved in both are difficult, a lot of training as well as practice are required. Subsequently, the apprenticeship is of a longer duration. Also, it is difficult to undertake sizeable jobs without a team. Team formation requires time. Thus a considerable amount of time is spent in the trade under someone until a worker establishes himself independently. Both trades have the choice of many new materials and a vast range of variety based on price. The same is also true with workers in the trade- higher skills demand a higher price but basic skills are available at a cheaper price too. Despite the variety of materials, techniques have not developed much. Both trades are practiced more or less in the same manner as were done a decade ago. Power tools, some adhesives, and some other minor materials are introduced in both trades, but no innovation affecting the trade as a whole has been introduced for at least the last five decades.[93] New and improved techniques are being introduced with the advent of more products like tile spacers or specialty paints. Workers trained in Middle East countries[94] are more aware and experienced in their use.

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[93] Special skills required for marble, granite or ceramic tile floorings, which were rarely used earlier, arrived with the use of these floorings becoming more and more popular. But these skills could hardly be termed as innovations since they already existed as traditional skills and underwent minor modifications of technique to suit the needs of the new materials.

[94] Skilled workers go to the Middle East countries in search of better income. Since these countries do not have local labor, and Indian labor being cheap, there is a great demand for skilled workers from India. Many good skilled workers go to these countries on a contract. In the course of their stay there, they are exposed to and learn the latest techniques being used there by American and European architects, engineers

5.6 Electrification and Plumbing:

Both, electrification and plumbing are new trades. Though not mandatory, basic education is necessary to understand the trade and most of the workers have at least primary education (till seventh grade). Both trades are not craft oriented and techniques used are straightforward and independent of hand skills. Thus there is no skill or technique that is developed specially due to a family tradition. Similarly there is no skill enrichment due to its adoption as a family trade over the last two generations. Since there are no predecessor workers to this kind of trades, there is no phenomenon of traditional craftsmen from other regions coming to practice these specific trades from other regions of the country. More local workers and those from the immediate surrounding regions are seen practicing these trades (this does not imply that there are no immigrants practicing this trade, but only states that the majority is of local workers and that immigration does not happen for practicing this specific trade). These trades are the representatives of most of the new trades being introduced in the building market today which depend less and less on hand craft and are more tasks to be done by human machines. Fenestration using aluminum sections, factory made assembly type furniture, ready made wooden and PVC doors, aluminum partitioning, etc. are all new trades not requiring any craft but a series of mechanical tasks for their completion. Also, most of these tasks could be learnt from the material supplier. Even if this means less dependence of the apprentice on his superior worker, most of the workers acquire the basic know how

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and construction companies. On the expiry of their contract, these workers return to India and thus are able to use or sometimes the only workers to know these techniques.

in by the same system of apprenticeship. The only difference is that the period of apprenticeship is reduced as tasks could be easily learnt. Plumbing is still more conservative in this regard, as a lot of complex and site-specific tasks are involved and a prolonged apprenticeship is needed to understand all the aspects of the trade. Both trades do not require big teams. The usual team is a skilled worker and his one or to helpers. Helpers may be permanently working with the same skilled worker thus forming a team. Workers may subsequently acquire the skills for the trade and start working independently by forming their own team.

Chapter 6: A discussion with field professionals

This chapter is a review of views expressed by various field professionals (architects and engineers) on the construction field, its workers and practices, building technology and innovations, etc. Practicing architects and engineers, at least in this part of the country, seldom write about the field. Thus there is a great lack of information and ideas exchange and any action thereof except within and confined to small private groups of practitioners. This occurrence too is informal and occasional. Feedback from the actual field is very important for the understanding of major aspects of this industry. Any research aiming to make recommendations for field implementation cannot be realistic without being aware of the ground realities of the field. Thus with the same aim, a feedback of people working in this field and other than the workers was found essential. Since any literature by field workers is virtually absent, hearing the professionals talk about relevant topics was the best way of knowing their observations and assessment of the practical side of the profession. This review is thus equivalent to a literature review about the construction industry in this region as perceived by architects and engineers. Architects and engineers are one of the decision makers in the industry with regards to design and technology employed in a project. Ideally, they are also in a position where they can grasp the situation of all- builders, clients, workers and the overall industry. A few also have worked closely with construction workers at some point of time in their practice. Thus they are better equipped and qualified to assess the field.

6.1 Construction Workers:

Educated people do not cherish working as construction workers and never become one. The lowest level of social class becomes construction workers. These people have low or no aspirations, no aims and therefore do not try to progress, to make use of skills, to organize and find work. They are satisfied with the daily wages and only care for a days work assurance. Despite low income, there is no attempt to work harder for earning more. Even when they are paid more, most lose it on drinking or other addictions instead of saving or making beneficial investments thereby remaining in the same economic condition. In general, workers lack a vision for the future, thus instead of progressing, they remain in the same state. Many just care for daily work and never plan for tomorrow.

For those who do plan for the future, there are economically better alternatives than putting energies in skill improvement in any construction trade. Better-qualified workers (also engineers) go to the gulf countries in search of better income. Becoming a builder is a lucrative proposition as it fetches better returns than investing money and effort in building up a workers' team or specializing in a particular technology. Money brings social respect that is glaringly absent in the workers' job. Also, the way to become a builder is known; there are plenty of role models to be followed, and lots of people to seek guidance and help, all of which are absent for any advanced skill acquisition or building an organization of workers for better and bigger work. Finding jobs is not a problem for specialized workers as they are scarce. But training opportunities are low and

the will of workers to deviate from run of the mill jobs that ensure enough pay is not strong.

It is a sellers market today and whatever the builders build is sold. Quality hardly matters in the marketplace. In this regard, whatever skills the workers have today are enough as they can build what sells.

Education of workers will give the workers a vision, a direction to follow and a sustained interest in working and developing the construction field and in return themselves. Presently, they have no education and no grasp of conceptual aspects of technology. They execute any job as told. There is no leadership in workers, no capacity to organize, and carry a technology / skill forward. They can do repetitive work but nothing new. Some architects do train workers, but as architects they too have limitations on time and resources to be spent on workers' training. Already skilled workers have preconceived notions of a certain job and therefore are more difficult to be taught any innovation. Unskilled workers on the other hand learn fast as it is there first job and skill. Compared to newly trained workers, traditional craftsmen are smarter in comprehending, learning and using new skills.

Workers are not asked for advice. They are to obey orders. Rarely would a worker have a chance to make suggestions. They will be creative only when challenged, which happens rarely. In this regard, workers will have a very small role in dissemination of technology.

6.2 Architects and engineers:

Architects, after starting their individual practice, are initially worried about financially supporting their new setup. So they take up most of the standard work that comes their way without much choice and also without opting for any innovations which if fails may

adversely affect their reputation and thereby their clientele. Once they get enough work, and are in a position to take occasional risks of trying something new, many hesitate to venture out and take the little extra effort needed. Few like to disturb their settled lives and prefer to continue doing what they were doing earlier as long as it fetches money. Priorities of architects differ. Architects who wish to make a niche/ identity for themselves, who have a sense of mission will innovate. And these are very few in number. Most do not want to be separate from the crowd. And this is an inherent part of the Indian culture. Other cultural factors like conformity to the existing norms and practices, conservative attitude, not enjoying work and perceiving work as a necessary evil are also responsible for lack of innovations. Cultural attitudes and economic condition are given constants that have to be worked with.

Pune also lacks architectural scholarship and activism that may boost innovations. Professors and experts are unaware of the field requirements, relevance of innovations etc. Education itself is obsolete. Unfortunately, professionals who themselves do not know anything opt for the teaching profession.

The only innovations sometimes seen are innovations in design and aesthetic treatments. Both these areas are subjective to judge and hence safe to innovate unlike technological innovations which either fail or are successful. Also, use or development of technological innovations needs sound technical knowledge, which is lacking in the architects (and also the architects' education) while design and aesthetic innovations need artistic creativity, which is again subjective to judge.

Architects rarely go to the work site- they do not feel the need or do not consider it as a part of their job. Most consider themselves to be far above workers in terms of

knowledge and so never realize that craftsmen could contribute something to the building process too. Humility is required so as to accept suggestions from a worker or work in consultation with him. As a result there is hardly any interaction between workers and architects, which is essential for any trade development to take place.

Most engineers too lack practical knowledge and therefore do not go on work sites to guide the workers or oversee the work. Most are even unaware of most innovations despite being in practice for a very long period.

6.3 Work system and culture:

Quality of technology deteriorates as it spreads. RCC illustrates this phenomenon better than any other technology. RCC has gone from bad to worse when it should have excelled given the number of jobs that are done using it. There is also a general deterioration in the quality of work. The prevalent work culture does not demand and result into quality work. There is a general apathy among all towards all work, characterized by non-insistence on quality, the callous and casual attitude, the over tolerance to mediocrity and shoddiness. No wonder than that technology too has developed into corrective products and techniques to cover up the mistakes rather than upgrading the quality. The development of masonry in 150mm wide bricks making plastering mandatory is a good example. In this respect innovations are very much related to what happens in the field.

But as desirable, better technology has not evolved from time tested indigenous building practices, materials or skills. Most materials and tools used today are western imports. There is very less relevant indigenous research and development and therefore no

continuity with traditional technologies is seen. But in today's market, at least through a limited clientele, indigenous crafts have started commanding respect and attracting patronage. MGK Menon had stated that the strength of Indian conservation movement lies in the continuity and development of its building crafts. The statement is true even for the home building industry if its aim is to house the millions of the country's homeless in an affordable way.

6.4 Innovations:

The result of the absence of relevant innovations and the use of contextually inappropriate technology is best exemplified in many rehabilitation and resettlement projects. Here, the users do not have any choice of technology. As a result they are unable to cope with and maintain buildings built with technology that is alien to them. But they only have a choice of either living with it or leaving the project. Many opt for the second. World Bank or other internationally funded projects are opportunities where innovations could be checked and employed. But unfortunately, the projects require the consultancy and approval of experts in government institutes with a typical bureaucratic approach, cynical towards new ideas. Most of these experts- many of them civil engineers- have no contact with the field for years and are oblivious to the context in which the projects are implemented. Their only sources of innovations are government research institutes (where they themselves may be working) where similar experts conduct research.

Cost of innovations is a determining factor too. Some innovations may be too costly for a developing country like India. Also, for any innovation to compete with already existing and established products, it is necessary to be at least equally if not more affordable than

the existing products. This is difficult to achieve since it takes time for a technology to settle in the marketplace and develop networks and systems that make it affordable. Established technologies are made cost effective over a prolonged period of use by which various ways to lower costs are tried out by promoters as well as users.

Anyone can potentially innovate. Innovation is not the privilege of any one profession. Engineers could go beyond their conventional boundaries of work and be creative. Workers may innovate too. But for them to innovate in projects employing mass production is difficult. They are more creative in smaller and more involved projects.

Apart from the voluntary innovations, there could be conditions compelling the architects and engineers to innovate. These could be specific functional requirements, or economic constraints or unavailability of materials. But most of the times, the compulsions are otherwise. Clients approving of an innovation play an important role in the development and diffusion of innovations. The biggest asset any person creates in his lifetime is his house. As a result, he prefers to build it with minimum risk and therefore not only an individual, but also the entire industry is more conservative than any other industry.

Print and audiovisual media is a major source of innovations for architects. In fact, it is a powerful source and effectively used by the building products industry. Industry can best promote innovations due to the large-scale use of media. Architects cannot do that due to financial constraints. Therefore their innovations are not widely known.

Using innovations amounts to breaking the existing setup- of workers, machinery, work organization, suppliers, etc. No contractor would be willing to do that.

6.5 The Public Works Department System:

The Public Works Department (PWD) of the government responsible for nearly all government construction jobs is a major employer of construction workers. Started by the British, it was the first system of allotting work, standardizing specifications and assuring quality of construction. It was the only system available then and was also followed for private jobs. It is used by the government till date and in many private jobs too. PWD system is contract based instead of departmental work.

Contractors were allotted work based on tenders invited from them. Work had to comply with the standard specifications and procedures listed for each job in the PWD handbook. Tenders had to be based on these specifications and procedures. Though the PWD system was good for getting work done and keeping check on its quality, it got corrupted. Also, it was not revived with the times. Old specifications and methods and compliance norms still exist. In this sense, it hampers innovations by hindering their introduction in the first place, as it does not entertain anything beyond its handbook. Some professionals are of the opinion that the system protected and thereby encouraged unqualified engineers in the government service. Since jobs were not done departmentally, they had no responsibility to execute the job and be on site. So, they could afford to be ill informed and apathetic to the developments in the field. The contracting system is profit oriented and compromises on quality. There are no performance based assessment provisions in the system. Most importantly, the contract system killed the mistry system (employing a team headed by a skilled worker- mistry) and replaced it with a contractor system headed by a person - the contractor- who was neither a skilled worker nor had any training in any other aspect of building construction. His only interest and aim was profit. Since this system was also

followed for private projects, the above disadvantages affected the entire building industry.

6.6 Builder- contractor system:

The builder- contractor system with traces of the PWD system has its own additional drawbacks with regards to workers and innovations. This system employs a vast number of make shift labor- people in desperate situations seeking any employment at any wages, without any skill or education and generally from a low social class. This is very akin to slave labor. This labor may not remain continuously in the field. They are underpaid, unsure of work continuity and undertrained. So imbibing a skill, doing something with it, improving on it, gaining expertise cannot happen and even if it does, there are no returns for the worker. This dissuades him from developing further.

Market forces and market demand are often cited as reasons for not introducing innovations and retaining the conventional building products and practices. But some professionals feel that market demand is just an excuse. It is a sellers market today. Buyers cannot demand. People buy whatever they get thinking it as the only best thing possible. No builder would therefore go beyond certain minimum limits to improve quality.

Buyers only demand the best from amongst what they see being sold in the market. They have no clue of what better products and quality could be possible.

Architects too report of builders asking them to work under restrictions of prescribed technology and cost. Economic slumps are periods when architects are in demand. Builders then depend on the architects' caliber to create something that will sell in the market. They will follow any architect at all costs who they are sure of. But when there

is a boom, builders are in charge. They can find ten architects for a penny to work for them on their terms then. Thus slump period is the time when architects can make builders use their experiments and dictate terms in terms of technology, design, etc.

Chapter 7: Diffusion and Workers- Present and Future

7.1 Technology and innovation diffusion

Some more discussion on technology and innovation diffusion:

It is observed that quality of a technology deteriorates as the technology diffuses further and further.[95] Many details of a technology are lost. The technology gets adjusted and modified to suit local resource and working conditions. The diffusion of technique is through workers passing on their skills to new workers. As seen in the previous chapter, most of this technique transfer is through informal training and observation and self learn methods. This results in further loss of detail and procedural correctness. As a result, technological degradation sets in as a technology diffuses in such a system.

Product innovations are supported by marketing and back-up systems of their manufacturing companies. Guidance in the form of suppliers is available to the workers using these products. Also, techniques to use most of the products do not differ significantly from existing techniques. Peer experience and market reports of the product are enough assurances to try using the innovation. On the other hand, technique innovations lack the backing of market promoters. Guidance and market presence is limited.[96] Consequently, performance reports and shared experiences are rare. As a result,

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[95] E.g. the quality of RCC is of the lowest level today despite its repeated and extensive use all over. Even the basic requirements of designed steel reinforcement, mix of concrete, proper bonding of steel and concrete are lacking not to speak of conceptual understanding. As one of the engineers interviewed for the dissertation remarked "RCC today is not RCC at all".

[96] Innovations by research institutes are transferred to the field through reports, newsletters or sometimes training programs for workers. As a majority of the workers are illiterate, and those who are literate have a remote chance to access this literature, it cannot act as a diffusion tool. Secondly, as seen in the previous chapter, field workers would enroll to learn a technology only if it is extremely essential for their survival in the job market. For a technology that has no market demand, enrollment for such training programs would be very less and it would be very difficult for the trained workers to find jobs that need this particular training. Training programs are rarely geared towards architects, engineers or contractors who, as shown in earlier chapters, have a greater decision making power than the workers regarding the choice of

workers perceive them as risky and are hesitant to use them. Therefore the rate of diffusion of product and technique innovations differs.

Work sites are the only training grounds for workers. Workers learn and practice a skill on their work sites. As mentioned in the previous chapter, workers would voluntarily use an innovation only after they are confident about it after frequent use. Thus for workers to voluntarily use innovations, it is essential that they are exposed to innovations on their work sites. Unless an innovation is not introduced on these sites and used repeatedly, it is unlikely that the worker will voluntarily use it in his own work. The choice of technology rests with architects/engineers, contractors or builders on such test sites. Consequently unless they introduce an innovation on their sites, workers won't be exposed to it, nor trained to use it. Some workers may not be even exposed to any innovations at all. Thus, if the decision-making construction professionals do not amply use innovations on sites, there would be very little transfer and diffusion of new technology.

Table 8 indicates that a considerable number of workers (33%) voluntarily use innovations on their independent jobs. So, to a certain extent, workers do play a role in technology and innovation diffusion. One of their major sources of technology and innovations are the construction professionals. If supply from this resource is scarce, workers cannot be held responsible for stagnation of technology.

Most of the sample workers have denied having any kind of architect/engineer- worker interaction. In most instances, it is not needed, as the jobs are identical in terms of technology used. If at all there is a deviation, instructions are given through the supervisors. Supervisors being responsible for getting the job done rather than teaching

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technology and therefore are the second largest source of innovations for the workers after the market place.

and making a worker understand what he is doing assign tasks to the workers to complete the job. Workers, being used as human machines remain completely without any clue of what they finally did.

Thus a vicious cycle is created. Innovations are not known t o workers because they are not widely used in the market for them to learn and find jobs using them while one of the factors for their not being widely used in the market is the lack of workers knowing how to use them.

7.2 A Conceptual Model:

A conceptual model is developed here based on key issues like skill formation and training, innovation transfer, and existing market conditions. It is only an idea and the author is fully aware of the possibility of its undergoing a number of modifications if it needs to be implemented. But even then, the core concept and issues remain the same and what changes are details of operation.

The need of skill formation by active training is evident from the present study. It is also evident that training institutes have not been effective due to various reasons stated earlier (chapter 3)[97]. Basic skills are acquired by the workers by working under other skilled workers. Training in basic skills therefore is not necessary. It is observed that 60% workers partly understand the conceptual aspect of the technology they use (concept as defined in chapter 3). If conceptual understanding along with improved skills is assumed sufficient for making a better quality worker with better quality output, then what is required is a way to train and upgrade these 60% workers in terms of understanding and

[97] A study of construction workers in Delhi showed that only 12.9 % of the total workers surveyed showed the willingness to undergo training. Workers distinguished between skill improvement and training. For

skills. Given the present system of operation of workers, the observations stated above about their training and the above identified training need and target group, a concept of a mobile training facility is proposed.

This facility is a group of trainers for different trades and innovations training workers on their job sites and moving ahead. Training takes place at the onset of the project or whenever the particular trades people are engaged. Thus training for different trades takes place at different times for the same project (e.g. training for concreting work will precede training for flooring work). Training is restricted to the technology being used for the project so that workers can put to application things that they have learnt and thereby, better understand the technology. Training is offered for any new technology so as not to dissuade the builder/ architect/ engineer from using an innovation for the lack of capable workers to implement it properly. Also, the responsibility of training workers does not lie with any of the above and so they need to concentrate only on their respective jobs. Most of the training is through hands-on work and only a part through other means so that a minimum amount of work time of workers is utilized. This is in the interest of the builder/ client as well as the workers who are eager to finish their day's quota of work. I.T.Is pay their trainees a stipend every month. The same system could be modified and the workers undergoing training may be paid a stipend. The amount may be deducted from the payment received by the workers from their employers (builders/ sub contractors/ clients). Thus it may also serve as an incentive to these employers to engage the training agency since they get better-trained workers at no extra cost and the training period paid by the training agency.

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them, training was associated with time away from work and loss of wages. More than 50% workers were willing to improve their skills.

The training agency, at least in its initial years has to find its own clients. Bigger size construction companies[98] could be the first group of clients. These companies have large projects and therefore larger number of workers working for them. Also, they may act as trendsetters for the successful use of innovations. These companies may also appreciate quality workmanship more than others in exchange of a little time of their workers. As larger number of workers are trained, the training will percolate faster to other workers through these trained workers. The next target group would be smaller contractors and builders. To reach workers beyond this level is possible only indirectly. During the training of other workers, some could be chosen and offered the training to teach other workers down the line. Such workers may be given a certification of quality and teaching expertise and encouraged to find employment with various agencies on various jobs with other workers. Here, with the knowing of his employer, this worker is required to train other workers on the job while doing his regular site job part time. Such volunteers could be created and actively recruited in the job market.

A large portion of construction workers comes from economically weaker and socially backward sections of the population. The socio-economic condition of workers together with their educational status and family conditions affects their work performance as well as their capacity and will to acquire, improve, learn and use skills other than what they are currently using to earn their living. The capacity of a worker to undergo training and perform better thus depends to a large extent on his economic and social empowerment. Ensuring a worker of his daily bread and a reasonable income is the basic need that has to be addressed for creating any conditions conducive to their capacity and skill

[98] Preferably companies handling residential projects on a big scale. Virtually, none of these companies have in house training facilities for their workers. Other construction companies could be clients too, since

improvement. Social upgradation and education of workers is a complex issue and is not dealt within the scope of this dissertation, but a major solution to the economic issue often proposed by researchers in the field is stated. Experts have advocated the granting of an industry status to the construction activity as a solution to the many ills associated with it. Construction should be legally recognized as any other industry and its workers given the same protection and benefits as their counterparts in other industrial sectors. This will also, to a certain degree, necessitate construction workers to be better trained in order to find employment. Granting an industry status will also have a great impact on the construction activity, and the housing market especially in terms of prices, quality control, and operation and organization of builder agencies, all of which will directly and indirectly affect the workers systems of operation and their quality.

And lastly more than a system, there needs to be an environment conducive for architects and engineers to develop construction technology further, not only through isolated research in laboratories but through an active involvement in site work and with a thorough knowledge of and sensitivity towards prevailing societal needs and the potential means and resources to satisfy them. The author is aware of innumerable interrelated factors that affect and effect change in a given system- be it the introduction of a small building product or a total overhaul of the workers operation systems and that individuals or even activist groups are hardly of any significant effect. But it should be recognized that collectively as a profession, these could make a significant contribution despite external and uncontrollable constraints. When traditional building systems were felt inadequate and under equipped to take on the challenges of the new world's demands, professions of architects and engineers evolved to hasten the pace of development for

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there is always an exchange of workers from one construction sector to another.

which traditional systems took long. If this aspect of the profession is forgotten or forsaken, the day may not be too far when the role of architects (or even engineers in the housing sector) may become redundant. After all, traditional craftsmen had no architects to work under, and the techniques they used and developed have long stood the test of time.

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Appendix:

Table 1: Housing need and shortage (Nos. in millions)

Year	Population	Households	Hsg. Units	Hsg. Shortage	Value in Rs. millions
1901	283.4				
1951	360.9	73.4	64.4	9	573130
*2001	1022.1	191.2	174.1	19.4	

*Projected

Source: Census of India, 1991Part 2 of 1992, Final Population Tables

NICMAR Construction Statistics, 1993

Table 2: % Distribution of urban households of pucca, semi pucca and kutcha houses (1991)

	Pucca (Permanent)	Semi Pucca (Semi- permanent)	Kutcha (Temporary)
India	73.1	17.57	9.33
Maharashtra	77.81	19.06	3.13

Source: Census of India, 1991, Housing and Amenities Table

Definitions:

Permanent - Houses with wall and roof made of permanent materials. Material of wall can be burnt bricks, GI sheets or other metal sheets, stone or cement concrete. Roof may be made of Tiles, slate, shingle, corrugated iron, zinc or other metal sheets asbestos cement sheets, bricks, lime and stone, stone and RBC/RCC or concrete.

Semi permanent - Either wall or roof is made of permanent materials and the other is made of temporary material.

Temporary - Houses with wall and roof made of temporary materials. Wall may be made of grass, leaves, reeds, bamboo, mud, un-burnt bricks or wood. Roof may be made from grass, leaves, bamboo, thatch, un-burnt bricks or wood.

Table 3: % Distribution of Household types of dwellings occupied

	Urban	Rural
Houseless	0.07	0.01
Independent House	52.35	82.56
Flat	17.08	2.71
Chawl	10.76	2.98
Other	19.62	11.65

Source: Census of India, 1991, Series 1, Part VII Tables on Housing and Household Amenities

Table 4: Construction Industry: Manpower Requirement (000 nos.)

	Total	Housing
1998-99	18125	10637
1999-2000	19852	11650

Table 5: Demand for Construction Manpower in housing sector (000 nos)

	Total	Engineers	Technicians	Non-technicians	Skilled Workers	Unskilled Workers
1998-99	10663	145	77	454	4197	5790
1999-2000	11650	159	84	470	4596	6341

Table 6: Requirement of Construction Workers in housing Sector by skill and trade (000 nos)

	Total	Unskilled	Skilled	Masons	Carpenters	Plumbers	Electricians	Others
1998-99	9987	5790	4197	3236	845	34	50	32
1999-2000	109370	6341	4596	3544	925	37	55	35

Source: India Construction Statistics, 1998, NICMAR, Mumbai, 1998

Table 7:Utilization of training places and success rates in I.T.Is in Maharashtra

	No. Of Seats		Success rate of exams (%)
	Sanctioned	Admitted	
Carpentry	1440	1440	78
Painting	398	352	82
Plumbing	384	352	78
Electrician	4128	3984	87

Building Constructor	992	992	64
Welding	2340	2292	72

Source: Performance budget 1988-89 Education and employment department, Government of Maharashtra

Table 8: Age profiles of sample workers

<20	20-29	30-39	40-50	>50
	9	16	5	