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Technology Transfer: Can Canadian Affordable Homes be Built in the Countries of Former Yugoslavia

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A Thesis Submitted to
the Faculty of Graduate Studies and Research
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of the Degree of Master of Architecture

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ABSTRACT

Following the disintegration of the former Yugoslavia. war distractions on one hand and major migration of the people on the other. the existing housing shortage in that region became more acute. The lack of large scale housing developments. weak and unstable economies in newly established countries. and transition towards privatization have resulted in a change in the main carrier in the housing industry from large construction companies to small-scale private ones. Technologically. however. the home-building industry is going "backward". adopting the use of conventional masonry as a main building method. which results in extended construction time and high prices.

The objective of this thesis is to identify alternative building systems for low rise housing. that can be applied to the market of countries of the former Yugoslavia. Six building systems. developed and produced in Canada. have been selected for this purpose. In order to compare them to existing system. the set of criteria for evaluation is developed. based on three major aspects: the technical aspect deals with codes and regulations. implementation. durability and other physical characteristics of building systems: the economic aspect compares costs: and the psychological aspect investigates the level of acceptance from both the builders' and homeowners' point of view.

The results of this research prove the complexity of the issue of technology transfer. Even though all evaluated building systems showed technical and. particularly economical improvements over the existing masonry. it is the issue of cultural acceptance that is the determining factor in the success of a new product. That is the main reason why building systems based on concrete would more likely be accepted over "light" frame systems. These results could provide directions of possible export opportunities for Canada's manufacturers of construction materials and components.

RÉSUMÉ

Après la désintégration de l'ancienne Yougoslavie. les conséquences des guerres d'une part et la forte migration de la population d'autre part. a entraîné un accroissement de la demande dans le marché du logement. Le manque de construction de logement à grande échelle. une économie fragile et instable dans les pays récemment formés. la transition vers une privatisation des marchés ont eu pour conséquence de déplacer dans l'industrie du logement les entreprises principales de grandes compagnies de construction vers des compagnies de petite échelle. Cependant. technologiquement. l'industrie du logement évolue "à reculons" en adoptant la maçonnerie conventionelle comme système de construction principal. ce qui a entraîné une hausse du temps de construction et des prix plus élevés.

Cette thèse a pour but d'identifier des systèmes de construction alternatifs pour des logements de petite taille qui pourraient être appliqués sur le marché des pays de l'ex-Yougoslavie. Six types de constructions conçus et produits au Canada ont été selectionnés à cet endroit. Pour les comparer avec les systèmes existants. j'ai développé un ensemble de critères d'évaluation reposant sur 3 aspects principaux: l'aspect technique concerne les codes et régulations. la mise en place. la durabilité et d'autres caractéristiques physiques des systèmes de construction. les aspects économiques compare les prix. et l'aspect psychologique permet l'analyse du niveau d'acceptation du point de vue du constructeur et de l'acheteur.

Les résultats de cette recherche démontrent à quel point les transferts de technologie sont complexes. Même si tous les systèmes de constructions évalués ont montré des améliorations techniques et même économiques par rapport à la maçonnerie traditionelle. le problème de l'acceptation culturelle est le facteur qui peut déterminer le succès du nouveau produit. C'est la raison principale pour laquelle les systèmes de construction en béton auront plus de chance d'être acceptés face à des structures dites "légères". Ces résultats

pourraient éventuellement indiquer des directions possibles pour les producteurs de matériel et d'éléments de construction Canadiens.

TABLE OF CONTENTS

CHAPTER 3:
FORMING THE EVALUATION CRITERIA FOR SELECTION OF BUILDING SYSTEM

LIST OF FIGURES

LIST OF TABLES

CHAPTER 1: INTRODUCTION

A significant part of the home-building industry in Canada is dedicated to worldwide export. Each market has its own specific requirements, however, and one universal formula can not be applied everywhere. Thorough research of a targeted market is needed prior to determining a product's feasibility.

This study deals with the potential for export by Canada's home-building industry to the countries of the former Yugoslavia. Analysis of conditions of housing markets in these countries will identify existing shortcomings and needs. Further, by developing criteria for evaluation and reviewing selected Canadian building systems, the author is better equipped to propose the guidelines for possible export opportunities for Canada's manufacturers of construction materials and components.

This introductory chapter is intended to present a general idea of what the study involves. The rationale of the study will set the background for stating the research question and objectives. Finally, the methodology used to develop this research is presented.

1.1. RATIONALE FOR THE STUDY

Unreasonably high construction prices, an inadequate building system that involves extended construction time, a building industry that offers a limited assortment of materials and components, and lack of sufficient financial assistance, both for developers and prosperous buyers, are the problems that burden housing markets in the newly established countries of former Yugoslavia (COFY). All of these problems are connected in a vicious circle, and cannot be solved individually. The author is aware that an examination of financial issues is essential in order to arrive at a solution to housing shortages, and that without adequate mortgage or loan programs from the governments. the situation in building industries in the COFY cannot be improved. However. the author of this thesis will attempt to examine the other. technical side of the problem. The lack of alternatives is forcing construction companies to go "technologically backwards" by returning to the use of masonry as the main low-rise single-family house building system. Its shortcomings include: high price. extended implementation time and. often. inadequate quality. It is important. therefore. to investigate what can be done to improve this.

The introduction of alternative building systems in the local housing market could be a part of the solution. In order to be accepted and effective. new building systems should offer better quality houses. reduced price, reduced construction time and the potential for use of local labour. which itself. would be more cost-effective. It should also be flexible enough to adapt to the requirements of local building codes. The introduction of alternative building systems would also create competition in the local building industries. thereby decreasing unreasonably high prices of the materials and components. All of these could create some equilibrium in the home-building industries of the COFY. making the solution of housing problems more accessible to the potential buyers. and therefore. increase the production of new. better quality houses.

As a world leader in building technology. Canada can play a significant role by sharing its experiences and by becoming directly involved in housing production in the COFY region. Canadian-made houses are exported throughout the world. and they are proving their adaptability and high quality in different climates. Canada Mortgage and Housing Corporation (CMHC) is researching the possibilities for Canada's housing sector to export to countries of Central and Eastern Europe (CEE) since the early 1990s. Their findings have helped to establish cooperation between Canadian builders and manufacturers and housing markets of CEE countries. and as a result. Canadian better quality houses are being built in Russia. Ukraine. Poland. the Czech Republic. Hungary. Slovakia. and in other countries. Due to a political turbulence and the civil war. the countries of former

Yugoslavia, with the exception of Slovenia and Croatia, were omitted from these studies. Nevertheless, some analogies with the situation in other CEE countries can be drawn: vast housing shortage, economic recession, similar method of building low-rise housing, and similar living standards.

As an architect interested in housing, and especially in building technology issues which can significantly improve the efficiency and quality of houses, the author of this thesis intends to explore and examine different products used by the Canadian home-building industry, in order to find out at which level technology transfer is possible. Coming from that part of the Europe, and being familiar with local housing industry, building codes and existing market , as well as with cultural background, the author will try to establish the basis for more detailed research which could lead to a more extensive implementation of Canadian products, in the future. Hopefully, this study will assist not only researchers, but the product designers to better understand the requirements of the market in COFY.

1.2. LITERATURE REVIEW

> *'Technology transfer' is a term that is nowadays used in different ways, but useful definition that has a currency of some twenty years refers to the process whereby the techniques and materials developed in one creative field, industry or culture are adapted to serve in other creative fields, industries and cultures. (Pawley, 1990)*

Even though this definition originated in modern times, the issue of technology transfer has been present in every aspect of human activity and progress since the beginning of civilization. Today, more than ever, the innovations and scientific discoveries outstrip the boundaries of its original field and find application in wide range of different fields. Also, the current state of the world economy dictates that the manufacturing of goods and trade goes beyond a country's borders, and inevitably moves towards globalization. In every aspect of production, technology and information flow, self-sufficiency of any kind cannot fulfill the requirements of the world's new market. Architecture is no exception, on the contrary, it was one of the first aspects of human progress that exceeded the boundaries of geographical, cultural and technological localism, since beginning of this century.

Housing, as a part of architecture that as a reflection of cultural, sociological and psychological characteristics of peoples' lives, remained more isolated from these changes for a while. Even in the developed countries, where the progress in other fields rapidly changes the way of everyday life, the practice of accepting innovations in the housing industry does not often follow with the same speed. There are many reasons for this: One of them is the fact that conventional new product development is a high risk business. As MacFayden explained in the conference "Next generation of housing technology" held in Orlando, in April of 1982:

> *"For each of 60 new product ideas introduced into a product development lab, there is hardware research and a prototype built. At that stage, the 60 initial ideas get knocked down to about 12 or 14 that have some technical viability. Business analyses drop the number to six or seven which undergo further development. Half of those enter a testing program and half of those, about two or three products go into a commercial use. One commercial success results."*

Bearing these facts in mind, the reasons behind why manufacturers of building materials have reservations toward accepting new products become more understandable. The other obstruction can be regulations already in place (either over-regulation or under-regulation), that are set for certain kind of existing structures, which can contribute to the reluctance to accept new ideas. The term 'regulations' here does not refer only to technical regulations, such as building codes, but also design codes and municipal regulations which govern the planning of the community, as well as the regulations of financial institutions which play the major role in providing the sufficient means for new developments. Overcoming these obstacles can be a long and exhausting process, which can be additionally influenced by fluctuation in the housing market, changes in the economy, real estates prices and interest rates. It is no wonder then. that even the most enthusiastic developers can find themselves sometimes discouraged by all these obstructions, which. together with the existing conservatism of potential homebuyers. are shaping today's housing market.

However. it would be wrong to conclude that the housing industry remained at the tail-end of technological progress. The idea of factory produced buildings started with Sir Joseph Paxton and his Crystal Palace in London. and the Victoria Regia water-lily house in Chatsworth. as early as the middle of nineteenth century. But. it was at the beginning of our century when this became an issue of serious consideration in housing. The architects of the Modern Movement realized that industrialization in housing could be an efficient solution. especially in the Europe, which was recovering from the destruction resulting from World War I. and where the shortage of housing was an acute problem. At the same time. on the other side of Atlantic ocean, the years of economic depression brought a new challenge for architects in the domain of housing. The need for small. affordable and fast-built houses emerged. and many manufacturers and designers undertook a task to develop an ideal model for the market. The idea of industrial-made houses (the housing equivalent to the Ford assembly line) was adopted as one of the possible solutions. and even the U.S. Department of Commerce officially defined the prefabrication:

> *"A prefabricated home is one having walls, partitions, floors, ceiling and/ or roof composed of sections of panels varying in size which have been fabricated in a factory prior to erection on the building foundation. This is in contrast to the conventionally built home which is constructed piece by piece on the site". (Herbert, 1984).*

Even though the concept of the "Ford assembly line" was not immediately and literally adopted in the housing industry. during the years the process of building the house has gradually shifted from the site to the factories. Especially in developed countries. where the high price of labour seriously affects the total price of the houses and requires high efficiency at reduced implementation time. almost all components are produced in factories, even if the house is not itself considered to be prefabricated. In other parts of the world, also, this process is taking place, although not with the same speed everywhere.

The demand for housing in some parts of the world is an issue that requires immediate solutions. Even though the greatest demands are for minimum cost housing solutions, the question of fast and efficient building of houses intended for the middle and even higher income populations should not be overlooked.

New materials and technologies developed over time, are spreading around the world, influencing local ways of building houses in different ways and at different levels, and slowly but irrevocably change the indigenous housing in many parts of the world. Some authors argue that imposing new technologies in housing speeds up this process and destroys the historical and cultural heritage of the region. The author certainly agrees with that. But, the example of the region of the countries of former Yugoslavia can probably speak for other parts of the world, also. Traditional houses, in terms of their look, layout, and building technology they were built with, do not exist any more. Diversities in climate, available materials and influences from neighbouring regions have resulted in the development of several types of traditional houses in that relatively small region.[1] But in the last 40 - 50 years it has changed, and the only way of building houses is that which uses semi-industrialized masonry in combination with reinforced concrete. Even the difference between rural and urban single-family house does not exist any more. Along with the other social and economical changes, brought by the modern lifestyle, the structure of the family unit is also changing, and demands different solutions for contemporary housing. Therefore, if the contemporary building technology that is in use in that region does not fully satisfy the need for efficiency and quality at an affordable price, there is no reason why alternative technology should not be introduced.

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[1] Along the Adriatic coast and in Montenegro, houses were traditionally built with stone masonry. In the north, in Panonic Plane, adobe was the main building material, in Serbia and Macedonia, the structure was heavy-timber with brick infills, and in the parts of Slovenia, Bosnia and Serbia which are rich in forestry, log houses were very common.

Exporting housing has become a growing practice in Canada in recent years. Penetrating a foreign market and introducing new products is not an easy task for any manufacturer. In the home-building industry, this can be even more difficult because of the conservatism that exists not only among the potential users (i.e. homebuyers), but also among the local builders and developers themselves who would rather stay inertly "on the safe side", without any attempt to improve their methods and products (Friedman, 1991). Entering the market of a foreign country, the process can be made even more difficult, because of the influence of various conditions. Climatic and other natural conditions, local building codes and legislation, the question of affordability and different price ranges, and social and cultural acceptance are just some of them. In order to succeed, every exporter should undertake detailed research prior to entering the new market, to find out the local people's preferences, and to adapt the product to make it most acceptable to them.

Canada Mortgage and Housing Corporation (CMHC) is researching foreign housing markets in order to identify their needs, and to help to promote and encourage the export of the Canada's home-building industry products. Their publications, even those not directly involved with the topic of this thesis, have been of great help to the author in terms of providing background knowledge about the issues of technology transfer to the other countries, its relation to the local cultures, building industries and economies.

With regard to technology transfer, the first question that immediately arise is the question of the economic justification. In the CMHC's workshop on housing opportunities in Central and Eastern Europe in Montebello, 1993, some very important findings are presented. Bill Teron of Teron International and Carlo Testa of Intelco presented their 'field' experiences , as builders operating within the Eastern European market for some times. Mr. Carlo Testa pointed out: "If construction costs for a house are $5000 in Russia, I have to make a house for $4200, and achieve Canadian quality at the same time". This he claims to be able to do.

Canada's home building industry proved itself as one of the world leaders in this field with its quality, efficiency and prices, and it is entering the worldwide market as a strong competitor with the others. Canada has proven its leading role in the area of building science. The various materials and components that transform the framing into a complete home have continued to evolve rapidly. Some Canadian innovations have progressed to the point that they compete against wood-frame itself. Metals, plastics and concrete composites are now positioning themselves, along with the advanced wood-composite products, to provide premium quality houses *(Canada's Exportable Housing, 1995).*

1.3. RESEARCH QUESTION

What are the appropriate alternative building systems that could be applied to the housing market of the countries of Former Yugoslavia (COFY), in order to speed up construction, and achieve good quality at affordable prices?

SUB-QUESTIONS:

Which types of building envelopes used in Canada's housing industry can meet building codes of COFY?

How will the home building industry of COFY implement new construction methods?

1.4. METHODOLOGY

In order to answer the research questions, the author will use the following methods:

First, the criteria for the evaluation will be established, based on: building codes, current availability in local building industry, need for highly qualified labour, and consumer acceptance.

The second part will present a review of relevant Canadian building systems for housing that are presently exported worldwide. Even though there are many different building systems in the current market. the author chooses to limit this thesis to a review of several systems which are essentially different from one other in basic principles. and which are already being exported. preferably into Central and Eastern European countries. Therefore the valuable experience of their exporters is included in the evaluation. The selected building systems are:

- wood-frame prefabricated structural system.
- light-weight steel frame building system.
- concrete / foam core sandwich panel system.
- plywood / foam core sandwich panel system.
- permanent insulated formwork / concrete system.
- PVC extrusion permanent form / concrete system.

Following that. each of the reviewed building systems will be evaluated. and compared to conventional masonry work that is commonly used in those part of Europe. This thesis will take the form of a critical review rather than exact rating.

To successfully complete this task. the author has undertaken thorough research in order to familiarize herself closely with all of these building systems. through books and CMHC publications. the Internet and direct contacts with builders and building system manufacturers.

1.5. OUTLINE OF THE THESIS

This study is organized into five chapters. In the introductory chapter. the author presents the rationale of the study and the subject of research. as well as the research question. The methodology used to develop this research is also presented.

Chapter 2 (Housing in the COFY) consists of three main sections. The first part presents characteristics that are common to all five newly established countries. such as:

existing housing conditions in the COFY. shortcomings and the reasons for their existence, and the state of the home-building industry. The second part presents each of the countries separately. and points to significant economical differences between them. The third section describes the building system for low-rise. single-family houses currently in use in that region.

Chapter 3 (Forming evaluation criteria for the selection of building systems) presents the process of creating the main tool for this research. The set of criteria. which approach the evaluation from technical. economic and psychological aspects. based on local building codes. current prices and home-buyers preferences. is defined.

Chapter 4 (Evaluated building systems) presents and analyzes selected building systems according to criteria established earlier. Short recommendations for possible adjustments to each separate building system are also given.

Chapter 5 (Summary and conclusion) is the final chapter. The author provides an analysis of findings. and outlines recommendations for possible methods of exporting Canada's home-building industry products to the COFY.

CHAPTER 2:
HOUSING IN THE COUNTRIES OF FORMER YUGOSLAVIA

2.1. INTRODUCTION

The former Socialistic Federal Republic of Yugoslavia (SFRY) is located in the South-eastern part of Europe, in the Balkan peninsula. The federation disintegrated recently into five independent countries: Slovenia, Croatia, Bosnia and Herzegovina, Former Yugoslav Republic of Macedonia (FRYOM), and the federation of Serbia and Montenegro (which retained the name Federal Republic of Yugoslavia).

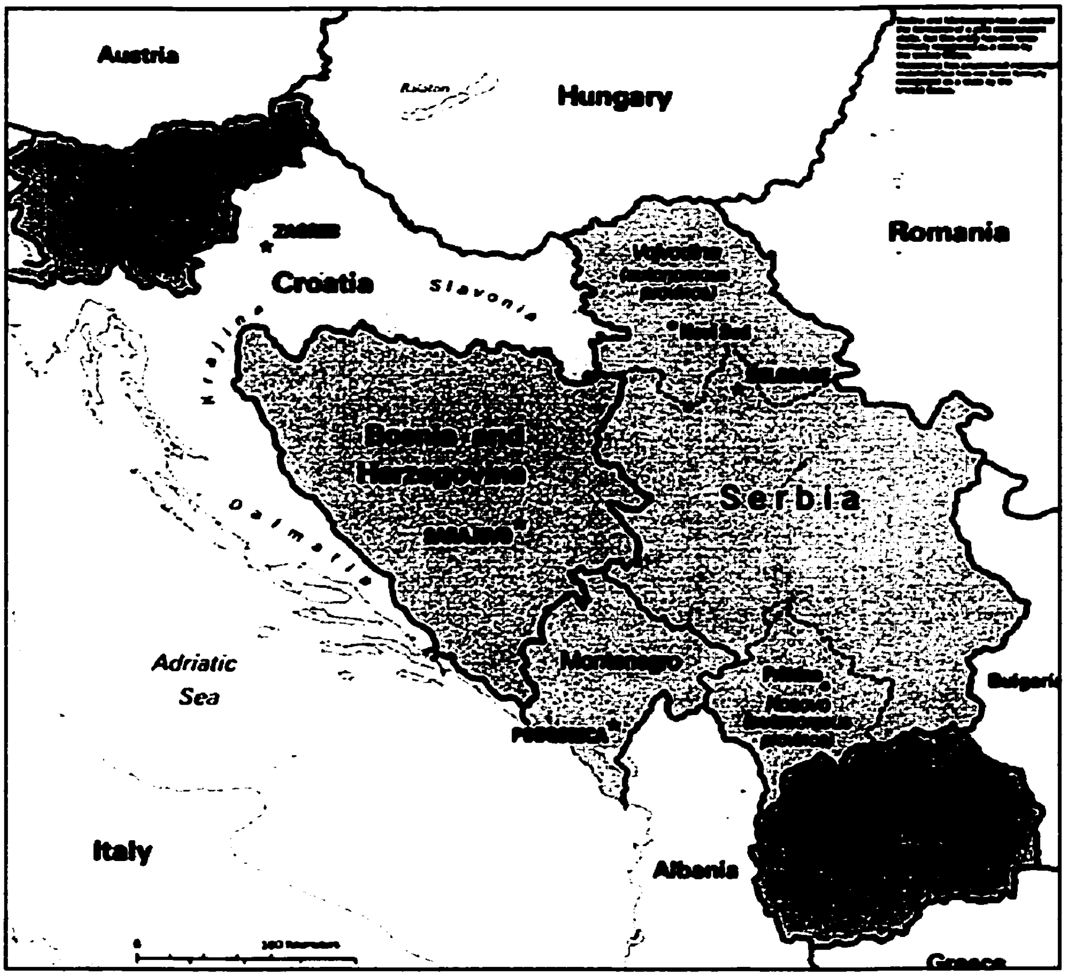

Figure 2.1: New countries which arose after the disintegration of former Yugoslavia.
Source: Internet: www.lib.utexas.edu/libs/pcl/Map_collection/europe/Former_Yugoslavia.jpg Retrieved from World Wide Web, January 1997.

During the past seven years since gaining independence, all of these countries have faced not only political challenges connected with the establishing the new states, but also economic troubles. The loss of a common market and resources, high inflation rates, and a decline in industrial output are just some of the problems, which were magnified by the difficulties of transition processes toward privatization. In addition, wars in Croatia and Bosnia and Herzegovina between ethnic groups resulted in large scale destruction of industrial capacity, housing, infrastructure, communications and trade channels. At that time, massive migration of the population occurred in order to escape war effected areas.[2] It is only since 1994 and 1995 that the economies in the COFY have shown a certain amount of growth, but, with the exception of Slovenia, they are still far from achieving the economic standard which they had in 1980s.

Housing shortages of varying degrees exists in every one of COFY, especially in urban areas. There are several reasons for this: problems inherited from the period of former SFRY, weak economies which severely influenced the purchasing power of the population, the lack of sufficient financing programs which would help both developers and buyers, almost total extinction of publicly owned rental units, which made up 35% of total housing stock before 1991, and the inability of the building industry to efficiently adapt to new circumstances.

2.2. BACKGROUND: HOUSING POLITICS IN SFR YUGOSLAVIA (1945 - 1991)

In the first part of this chapter, the author of this report will give an overview of housing politics during the years before disintegration, because it greatly influenced the present housing situation in the COFY.

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[2] According to UNHCR data, there is more than 700,000 refugees registered in FR Yugoslavia, 380,000 in Croatia and 320,000 in Bosnia and Herzegovina. There is, also, significant number of refugees from former Yugoslavia in other European countries, as well as in Canada and United States.

After World War II, only 19% of the population of SFR Yugoslavia lived in urban areas. Rapid industrialization, along with the low agricultural prices resulted in migration of the people from rural areas, and by 1991, more than 50% of the population lived in the cities. Housing was an important part of the construction industry: more than 3.5 million dwelling units were built over the 1953 - 1984 period. About one third of this was built with public money, and the rest with private resources.

Unlike some of the other Eastern European countries, in SFRY, social and private sectors could be clearly distinguished. The two types of producers operated under completely different conditions. Several housing reforms had been introduced between 1945 - 1991, in order to decentralize housing from government by the state. In these reforms attention was given predominantly to new housing production by the social sector (i.e. of building companies being 'state companies' in the first period, 'enterprises' in the second, and 'basic organizations of associated labour' in the third period beginning in 1974) *(Mandic, 1992)*. The entire social sector was predominantly oriented toward high-rise apartment buildings in urban areas. This type of housing production has been perceived as virtually the only promoter of housing provision, and was supported with the best site and serviced land, and financing through favorable loans from commercial banks. Figure 2.2 shows

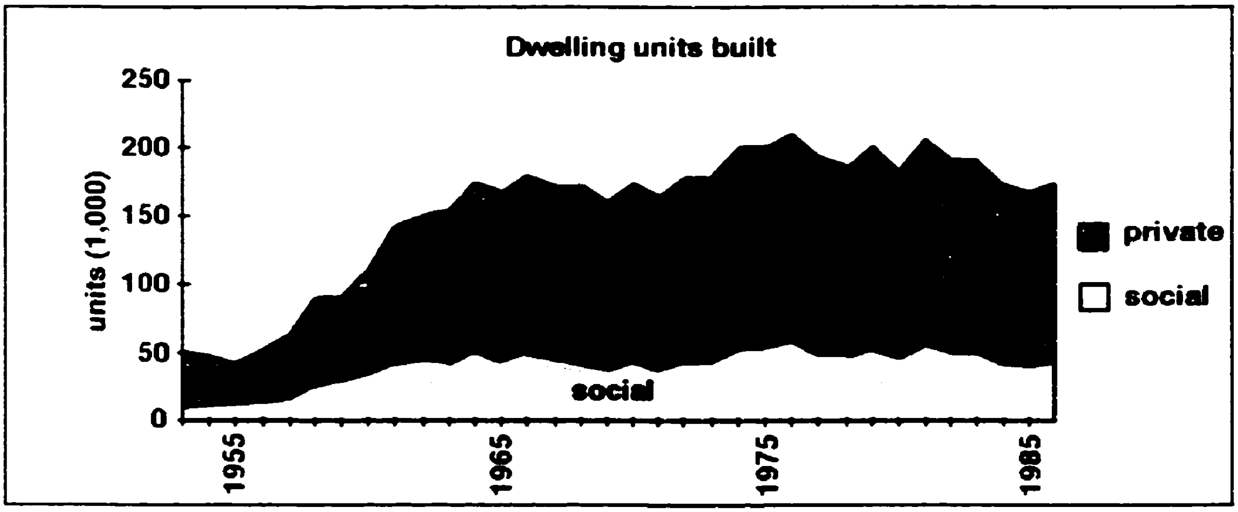

Figure 2.2: Dwelling units built in SFR Yugoslavia and the relations between two sectors.
Source: Yugoslavia: statistical review 1945 - 1985 (1986).

that even in the most successful years social sector production did not exceed 40% of total dwellings built, and in the beginning of the 1980s, only about one-fifth of all dwellings in the existing housing stock was socially owned *(Nord, 1992)*.

Reasons for this disproportion could be found in the way that the social housing sector was organized. Almost the entire housing stock in this form was built as rental property. This type of housing was extremely desirable because of very low rents.[3] Naturally, these amounts were not enough to pay for even the basic maintenance of the building, not to mention for providing enough funds for further investments. On the other hand, 'close relations' between large building companies and the municipal-level state administration provided each large building company with its own 'municipal terrain' and opportunities for housing construction there. Competition between construction companies were avoided, and the building industry easily kept the supply well below demand. Under these circumstances, prices could rise beyond all rational limits *(Mandic, 1992)*. What usually happened was that, faced with excess labour capacity brought about by declining economic activity, construction companies tended to stretch out the completion of housing projects as long as possible in order to keep the work force occupied. Housing authorities had little incentive to control costs, since they received funding with easy repayment terms from the central government *(Telgarsky, 1991)*.

2.2.1. SOCIAL SECTOR

Big construction companies with usually more than 1000 employees were the main carriers of the construction business in the social sector during the existence of SFR Yugoslavia.[4] They were organized to be completely self-sufficient: with their own design department with several teams of architects, technicians and draughts-people, urban plan-

[3] In 1983, no more than 2.8% of all household expenses went on housing, as compared, for example, with 5.5% for tobacco and beverages *(Nord, 1992; Statisticki godisnjak, 1986)*.

[4] In 1987, in Yugoslavia's building industry existed 87 companies with more than 1,000 employees each, while in same year, in United States was 77 companies of that size *(Annual bulletin of housing and building statistics, 1992)*.

ners, civil and mechanical engineering departments. Besides that, there was a large bureaucratic force of managers, accountants and market specialists. Every company also had its own operative department with several hundred or even thousand employees, mainly craftsmen and their apprentices and complete mechanical facilities. They were often specialized in other types of building as well as housing.

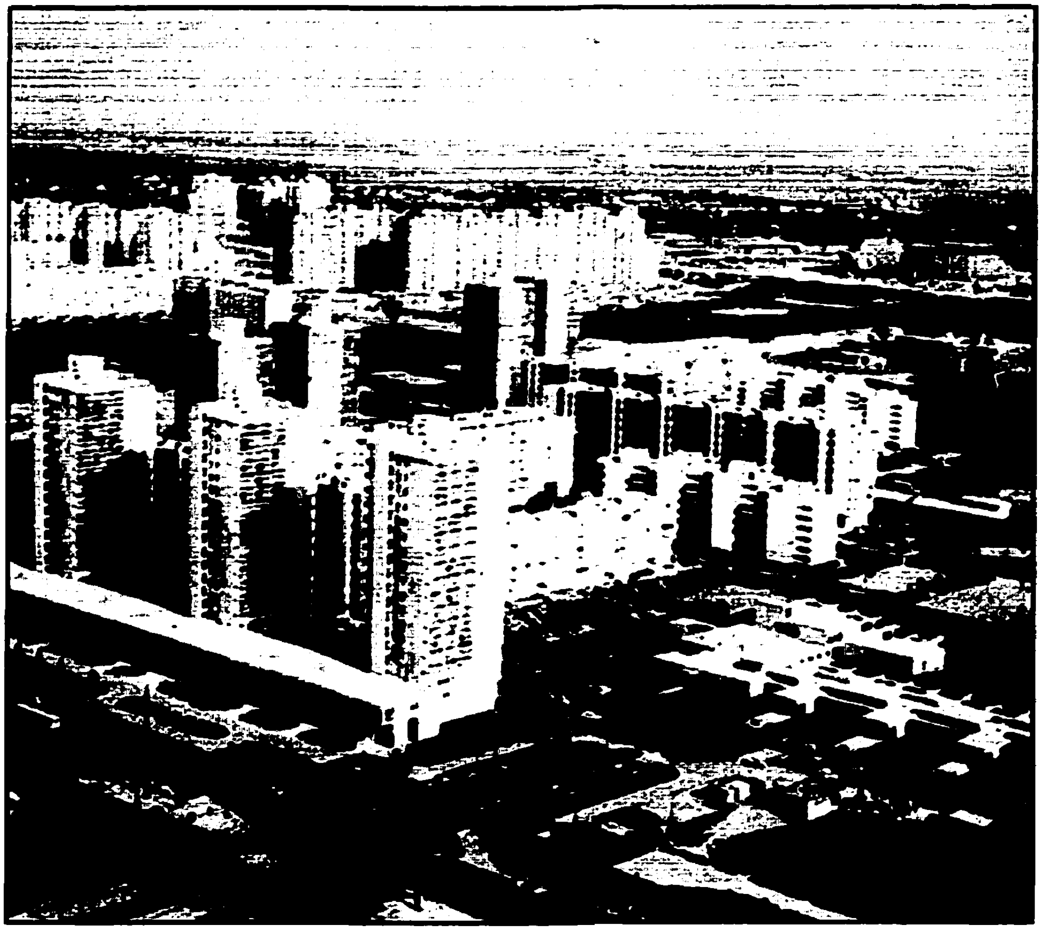

Figure 2.3: The New Zagreb housing estate.
Source: G.P. 'Tempo' (1980).

The main structural material in SFRY was (and still is) reinforced concrete. Steel structures have never been very popular even for a commercial buildings because of the high price of good quality structural steel, and because of the lack of qualified craftsmen to build them. In the period of highest production of those large scale apartment blocks that are the main characteristic of the social sector housing, industrialized building technologies have been used.[5] The principles of prefabrication was a major consideration in the design process, as well as in the process of realization. Every bigger construction enterprise developed its own prefabrication system, and whether they were using bearing walls or post-and-beam as a main structure, it was common for all of them to be heavy, reinforced concrete elements that could only be manipulated by cranes. Even though everybody used the unified modular system, the elements were totally incompatible between different construction companies.

After the initial enthusiasm, prefabrication became less desirable, because it appeared to be very limited. Together with the lack of new large scale developments, it lead to gradual abandance of these building systems. So, ironically, the industrialized building system, instead of being more affordable, failed because it did not have a chance to overcome its inflexibility. Nowadays, when large scale housing development has ceased to exist, the most common building system for multi-story buildings is much less industrialized. The bearing structure is still made out of reinforced concrete poured on site and after it hardens, the infilling is made of masonry.[6]

2.2.2. PRIVATE SECTOR

On the other hand, private sector production was (and is) oriented toward detached family housing units in rural areas and city outskirts. This private - social sector dualism is also noticeable in housing morphology, since intermediary types of housing such as semi-

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[5] The housing construction in the social sector in this period resulted in the large scale additions of new housing areas in many of main towns, creating completely new urban areas such as New Belgrade, Split III and South Zagreb. In New Belgrade, a new city with the population of almost 300,000 people was built in the area of 588 hectares. On somewhat smaller scale, Split III was built with planned 50,000 population alongside the existing city of Split. New housing areas were typically divided into neighbourhoods of 5-10,000 inhabitants, each with their own collective infrastructure - kindergartens, primary schools, markets and local community centres *(Bassin, 1984)*.

[6] The architecture of housing has also changed over the years. The influence of Le Corbusier and CIAM and the Ville Radieuse was considerable in Yugoslavia, and sequences of housing blocks up to 30 stories high appeared in the 1960s with densities of up to 600 persons per hectare. Such new construction has since been seen as undesirable, mainly for technical and safety reasons, and now, the general maximum height is up to nine floors.

detached and townhouses virtually do not exist.

Individual households who built their own dwellings relied mainly on their own financing and labour. Those who were building the houses in the private sector could be divided into three groups:

- unpaid and unregistered labour (self - help practice),
- paid, yet officially unregistered illegal labour,
- paid and legally registered services of small private firms, mainly craftsmen *(Mandic, 1992)*.

The first and the second categories belong to the so called 'gray' or 'informal' economy. Peter Bassin (1984) calls it: 'black housing', and according to him up to 30 % of all individual housing is built this way (i.e. without a building permit, located in the city peripheries and often without appropriate infrastructure). In his book *Toward market oriented housing sector in Eastern Europe (1991)* Jeffrey Telgarsky describes:

> *Due to the shortage of building lots, construction by private individuals without planning approval or permission to build is widespread in urban areas. The shortage is mainly a reflection of the town planning process which greatly underestimated the demand for lots to accommodate single-family homes; higher density development of flats was apparently envisaged. Even where land is available for construction of single-family units, the costs of infrastructure provision is often too high to be affordable to the household. Instead, households build under the threat of demolition, using old or recycled materials to keep costs down and limit their potential losses. This is a competitive solution to the housing shortage, but a very tenuous one.*

The author of this paper would like to point out that these settlements are very much different from the squatter housing in Latin America, for example, even though the principles of their origin is similar. Built using solid masonry, they are usually 3 or 4 floors high, where the ground floor is often intended to be used for commercial purposes, which provide additional income to the family. Built without formal design, they are usually oversized, intended to house the extended family of the owner. Because of the high prices of building materials, building time extends over several years. Some of these houses remain unfinished (usually on the upper floors) even though the family moves in and lives downstairs. As the size of these settlements grew over the years, the authorities found it more and more difficult to fight this process, and gradually the idea of demolishing was abandoned, especially in cases where their location did not come into conflict with the General Urbanistic Plan. Eventually, these settlements were recognized by local planning authorities, and included into the city limits.

Figure 2.4: Houses built without the permit on the outskirts of Belgrade. This settlement, Kaludjerica, has more than 70,000 inhabitants.
Source: Photograph by author (1995).

2.2.3. FINANCING

Owing to the crucial role played by one's place of work in the bid to obtain the tenancy right in social rent housing stock, a person's position in the company together with the success of the enterprise in making profits were important factors. Official statistics also confirmed that highly skilled workers, whether white or blue collar, had a competitive advantage and that those with the highest positions were much better off than the rest *(Nord, 1992, quotes Statisticki bilten 1675, 1988: 11).*

Clearly, the situation was paradoxical: those with higher incomes who could afford to invest in building their own home actually had easier access to low rent apartments, and the majority with more modest means were left to make their own housing arrangements.[7] Lars Nord gives an example in the chapter about Yugoslavia that he wrote for the book: *Reform of housing in Eastern Europe and the Soviet Union (1992):*

> *"...no wonder that a survey of young workers' expectations of how to find somewhere to live indicated that only a quarter of them believed that any possibilities existed in the rental sector; 15% hoped to get a loan and build their own house; 13% were lucky to inherit the dwelling and 12% saw an option in buying an apartment with borrowed money" (Nord, 1992 quoting Bezovan, 1987).*

In terms of financing, individuals could finance private home-ownership by making downpayments and obtaining loans through their work places or commercial banks.[8] A portion of housing construction funds are set aside for financing private ownership. But a major source of private funds for households finance home ownership was (and still is) through contributions from household members employed abroad. It is estimated that between 1965 and 1989 over 700,000 migrant workers sent between $30 and $35 billion in remittances back to households in Yugoslavia *(Vilogorac et al., 1990).* Of this amount, more than 70% was invested in housing, although a portion was also spent on renovation and maintenance of existing housing. Mortgage and housing loans were also provided by

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[7] "It has been pointed out by a number of observers that the dominant type of the housing provision of the upper social strata has been rental accommodation (i.e. the least costly), while the dominant type of the lower strata has been self-help building (i.e. more costly not only in terms of effort but also in terms of finances). Such a pattern of inequalities in housing provision may be - with minor variation - attributed to all reform periods.". *(Mandic, 1992).*

[8] "In SFRY, the commercial or the 'basic' banks were not state owned. Basic banks are owned by the "founders". Yugoslav enterprises can create banks with their own capital. Worker councils can also own and manage banks. In practice, banks are subservient to their founders, they are usually underdeveloped, overly decentralized and inefficient". *(Telgarsky, 1991)*

commercial banks, but this type of financing was much less common. Only about 1% of a banks' total assets accounted for home mortgages *(Vilogorac et al., 1990)*.

In the late 1980s, the Government tried to bring some market discipline within the social sector, and authorized construction of 30,000 dwellings for sale at market prices. The response was poor however, since construction companies did not have enough working capital to finance their own developments and households were unwilling to finance the construction with their own savings or with expensive unfavorable loans. Since 1988, when hard budget constraints were imposed on construction enterprises, the home building industry has contracted substantially *(Telgarsky, 1991)*.[9]

In the early 1990s, as a part of privatization process, the Housing Act was introduced; this enabled tenants to buy the unit for which they had a tenancy right. As a result of this, the ownership rates have been increased from 59% to more than 85% in urban areas. In rural areas, the percentage of ownership has always been more than 95%. The newly introduced economic program manage to stop inflation and started to rebuild the economy in an effort to help the transition toward privatization, but this was not effective. At this time, political turbulence erupted, and in June 1991, when Slovenia declared independence, the disintegration of SFR Yugoslavia began.

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[9] Indices shows that in 1980, in SFRY were 632,000 employees in the construction industry (in the social sector only). In 1986, that number declined to 94,000 and in 1986 to 86,000.

2.3. COUNTRIES OF FORMER YUGOSLAVIA; PRESENT STATUS

Even during the existence of SFRY, all federal republics were not equally developed, either economically or industrially. This, along with the additional economical collapse which occurred with the break-up of the country, and difficulties produced in some countries by war, affected the status quo dramatically. The next section of this chapter will present a brief introduction of each of the newly-established countries, describing their economic status and its affect on the housing in those countries, with the aim of pointing out possibilities for future developments in the home-building industry.[10]

COUNTRY	Population (million)	Density (population per km^2)	Urbanization level (%)
Slovenia	2.05	98.2	50.1
Croatia	4.80	54.5	54.3
Bosnia and Herzegovina	3.20	-	-
FR Yugoslavia	10.52	102.9	51.3
FYRO Macedonia	1.95	80.7	58.7

Table 2.1: Population density and urbanization level in the countries of former Yugoslavia.
Source: World Bank, UN statistics, Governmental statistic offices (1998).

2.3.1. SLOVENIA

Overview: Slovenia is located in the North-Western part of the region that was occupied by Former Yugoslavia, with a total area of 20.300 km^2. It borders on Italy, Austria, Hungary and Croatia, and it has short coast to the Adriatic Sea. Slovenia's climate is Mediterranean at the coast, and continental inland, with mild to hot summers and cold winters. The total population reached 2.05 million in 1995, of which about 50% lives in urban areas. The largest city is Ljubljana, the capital, with a population of 330,000.

[10] Sources for all statistical data in this chapter are: Economist Intelligence Unit, World Bank, UN statistics and local government statistics.

Slovenia is economically the most prosperous country of all the countries of former Yugoslavia, as well as of the other countries of Central and Eastern Europe. The Gross Domestic Product (GDP) per head was US$ 9,326 in 1996, and the inflation is controlled under 9.7% per year. The average monthly salary in same year was US$ 610. The unemployment rate is a relatively high 14.4%. Slovenia is member of GATT, European Free Trade Agreement (EFTA), and the Central European Free Trade Agreement (CEFTA). It is also a founding member of World Trade Organization (WTO), and has the association agreement with European Union.

Housing conditions: The 1991 Housing Act and 1993 Law of Denationalization regulated the possibilities of buying socially owned dwelling units and returning nationalized units to their former owners. As a result, in 1994 88% of total dwelling units in Slovenia were privately owned and owner occupied. The rest (12%) are for rent and are divided between publicly owned (9%) and privately owned (3%). The average floor space is 30 m^2 per person, which is generous compared to regional standards, but insufficient in reality indicating the existence of some overcrowding. Water and electric power supplies are fully comparable to Western European standards.

Housing market: The average price of new houses in Slovenia is approximately US$ 87,600. Bearing in mind that the average annual wage is US$ 7277, it is easy to conclude that the ratio between the price of the house and income is quite high (almost 12). However, there are several ways of financing the building of new homes. Besides using private savings in hard currency, there are loans available, provided by banks, which will remain state-run for some times. There is also a National Housing Fund which grants the loans for community groups for building non-profit rental houses.

According to the 1994 statistics, there are 642,000 households in Slovenia, compared to 620,000 housing units, which creates a shortage of about 20,000 units.

2.3.2. CROATIA

Overview: Croatia has a long coast to the Adriatic Sea and it borders Slovenia, Hungary, FR Yugoslavia and Bosnia and Herzegovina. Diversity in topography results in climatic variation: Mediterranean along the coast, continental with cold winters and hot summers in the highlands, low mountains and flat planes. Natural disasters include frequent and vigorous earthquakes. The population of Croatia is 4.8 million (excluding 380,000 refugees): the percentage of urban population is 54%. The capital city is Zagreb, with 727,000 inhabitants.

Economically, Croatia holds second place among the countries which emerged after the disintegration of the former Yugoslavia, but it is still far behind Slovenia. The gross domestic product per head in 1996 was US$ 3,972. The inflation rate is well under control and it is lowest in the region: 3.5%. In recent years, the Croatian economy is showing consistent growth, it should be pointed out that it contracted more than 35% between the 1990 and 1994, due to the war. The average wage in 1995 was US$ 355.

Housing conditions: After the 1991 law of privatization of socially-owned dwellings, the percentage of owner-occupied units reached 85%. Publicly owned rental units make up the next 10%, and privately owned units for rent are 4% of the total number of dwelling. The average floor space per person is 22.1 m^2 (21 m^2 in Zagreb), which is low by European standards. Large migrations to urban areas has produced a deficit in dwelling units in the cities, while approximately 8% of the houses in rural areas are currently vacant. The urban population enjoys higher quality houses (water supply, electricity, sewage and even district heating), because the urban areas have traditionally attracted larger share of government investments in infrastructure and services. Still, substandard houses makes up 14% of the total housing stock in Zagreb.

The acute shortage in dwelling units was increased by war destruction. It is estimated that more than 27,000 houses and 210,000 apartments were destroyed between 1991 and 1993 in Croatia.

Housing market: The production of new houses in Croatia decreased dramatically in the early 1990s: only 9,700 new units were built in 1994. The reason for this is decreased governments investment in housing, and insufficient private investments. The cost of new houses has increased to US$ 1,115 per m^2 (US$ 104 per sq. ft.), land excluded, and without appropriate financial help from the banks and agencies, it is impossible to buy a house with an average annual income of US$ 4,260. Currently, the main financial source for the purchase of new housing is private savings in hard currency.

It is estimated that current demand for housing in Croatia is 10,000 units per year. This number excludes the number of 210,000 units urgently needed to compensate for the war damage. Even though the Croatian government provided US$ 19.8 million for this purpose, without international help this task can not be fulfilled.

COUNTRY	Slovenia	Croatia	Bosnia and Herzegovina	FR Yugoslavia	FYRO Macedonia
GDP ($ bn)	18.6	19.1	1.7	15.7	4.5
GDP per head ($)	9,326	3,972	501	1,489	2,263
Consumer price inflation (%)	9.7	3.5	-	93.1	3.0
Current account balance ($ bn);	0.0	-1.5	-	-1.7	-0.3
% of GDP	0.3	-7.6		-10.6	-6.5
Exports of goods ($ bn)	8.3	4.6	-	1.8	1.2
Imports of goods ($bn)	9.3	6.8	-	4.1	1.5

Table 2.2: Comparative economic indicators, 1996
Source: EIU, Country Profiles, 1997-98

2.3.3. BOSNIA AND HERZEGOVINA

Overview: The Republic of Bosnia and Herzegovina is located in the central part of the region, bordering Croatia in the North and West, and FR Yugoslavia in South-East and East. The 12 km long coast provides access to the Adriatic sea. The climate is Mediterranean along the coast and deep inland along the Neretva river valley, and continental, with cold winters and warm summers in the rest of the country. Western and central parts of the country are characterized by the Dinaric mountains and highlands. The terrain lowers gradually, flattening into plains in the north and north-east along the Sava river. Some parts in the north and entire southern part of the country are seismically unstable. According to the last census held in 1991, the total population of Bosnia and Herzegovina was 4.4 million. But in 1995, the UNHCR estimated that population declined by more than 1 million.[11]

Bosnia and Herzegovina was severely devastated during the four year war between three ethnic groups: Serbs, Muslims and Croats. The war ended with the Dayton agreement in November 1995. According to the constitution set up at that time, the Republic of Bosnia and Herzegovina consists of two entities, the Federation of Bosnia and Herzegovina and Republika Srpska (RS) in a loose state. The war brought total economic collapse: the gross domestic product (GDP) per head was US$ 501 in 1995, compared to US$ 1,979 in 1991. Much industrial capacity was destroyed, as well as housing, infrastructure, communications and trade channels. Post-war reconstruction will almost certainly be the main purpose for building activity in the near future. According to World Bank reports, over 250,000 jobs have been created through reconstruction-related activities. Still, the unemployment rate remained very high: over 50% in mid-1997. The recovery process has been territorially uneven, with the Federation doing better than RS. The average wage in the Federation reached US$ 170 in the first quarter of 1997, and in the RS it was only US$ 45. Widespread poverty will remain as humanitarian assistance to the region declines, and the effects of economic recovery take time to be felt.

Housing conditions: Pre-war housing stock in Bosnia and Herzegovina was estimated at 1.3 million units, of which 80% were privately owned. The quality of the con-

[11] The United Nations High Commission for Refugees (UNHCR) estimated that around 250,000 were killed, while others fled to escape the war. In addition, there is around 300,000 people settled in from other parts of former Yugoslavia.

struction was high; almost half of the housing stock having been built after 1971, and more than 90% after 1945. The pre-war percentage of the urban population was 62%, but massive migrations occurred during the war when people headed to cities in order to escape destruction.[12] As a result, the pre-war population in some cities almost doubled. This put a great strain on housing, infrastructure and other services in towns, while large parts of the country have become underpopulated. A government survey in 1995 estimated that 63% of housing units have sustained at least some damage, and 18% of units have been destroyed (defined as more than 60% damage to the property).

Obviously, the priorities are to house the displaced people and to increase usable stock by repair and reconstruction. Some reconstruction activities are already taking place, but there are many obstacles, such as an inadequate supply of building materials, infrastructure and financial resources, as well as conflicting ownership claims.[13] However, it is clear that immediate solutions cannot be achieved without the help of the international community.

2.3.4. FEDERAL REPUBLIC OF YUGOSLAVIA

Overview: FR Yugoslavia is the largest country to emerge after the disintegration of the former SFRY, both by territory and the population. It consists of two federal units, Serbia and Montenegro. It borders Hungary in the North, Romania and Bulgaria to the East, Macedonia and Albania to the South, and Bosnia and Herzegovina and Croatia to the West. The terrain is characterized by fertile plains in the north - part of the Panonic Plain, low hills in the central part and tall mountains in the eastern and western parts of the country. The 200 km long Adriatic coast provides direct contact with the Mediterranean region through Bar port. The other means of access is through the Danube and Sava rivers.

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[12] According to the local definitions, the term "urban" refers to cities with more than 50,000 inhabitants.
[13] Both Croatia and Bosnia and Herzegovina passed wartime housing laws, which are still in effect, that empower their governments to confiscate homes abandoned by citizens fleeing ethnic violence. Some people tried to return after the war, only to find that their homes were "reassigned".

which have three large ports: Belgrade, Novi Sad and Apatin. The climate is Mediterranean along the coast and continental inland. The population of FR Yugoslavia is 10.5 million, but this number excludes more than 725,000 refugees from the war in Bosnia and Croatia.[14] The capital is Belgrade, with a population of almost 2 million.

The collapse of the economy caused by the break-up of the former Yugoslavia in 1991, and the western sanctions against Serbia-Montenegro introduced in 1992, led to hyperinflation of 117 trillion %, in 1993. Although an economic stabilization program introduced in early 1994 result in big improvement, the economy of FR Yugoslavia is still very weak. Even if this growth continues at the same rate over the next decade, in 2007 Yugoslav GDP per capita will be only one third of what it was in 1980. *(Kostic, 1997)* The inflation rate by the end of 1996 was 93%, and the GDP barely reached US$ 1.500. The obstructions in the process of privatization and internal political instability are the greatest obstacles in economic recovery. The unemployment rate is still high at over 26%. The average monthly wage in April 1998 was US$ 90 (Can$ 125), but many people earn a living through different kinds of black market activities.[15]

Housing conditions: According to the 1995 statistics, there were 3,124,000 dwelling units in FR Yugoslavia, out of which 52% were in urban areas, with average of 3.4 persons per unit. Average useful space per person is 20.0 m^2, which is considered very low by European standards.[16] As in the other countries, the Housing Act enables the tenants in publicly owned rental units to buy them under relatively favourable conditions. Still, there is an acute housing shortage in urban areas, especially in Belgrade where the population

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[14] According to the information of UN High Commission for Refugees (UNCHR) and Republican Commissariat for Refugees of Serbia, in 1995 there were 725,526 registered refugees in FR Yugoslavia.

[15] "Yugoslavia is still excluded from international financial institutions, which means that there are no international sources of statistics about the country. The IMF, the World Bank, the OECD and the European Bank for Reconstruction and Development (EBRD), do not publish data for Yugoslavia. All data presented are relying on national sources, which have had to fill a big breach". *(Country profile: Yugoslavia, Macedonia, 1997-98).*

[16] As it was mentioned before, this data does not include more than 700,000 refugees. Of this number, more than half (330,000) lives with close relatives or friends.

has significantly grown in recent years, while there are vacant houses in rural areas.

Housing market: Although the share of construction in the total GDP is 6.7%, the production of new homes is lagging behind considerably. The main reason for this is the high disparity between the average income and the cost of the house. The average price of a new house in Belgrade is currently Can$ 750 - 1100 per m^2, which is equivalent to a price of close to Can$ 100,000, for a house, land excluded. The lack of financial assistance makes it almost impossible for an average family to solve its housing problem. Only those in the upper income strata and those whose family members work abroad can afford to buy a house by paying cash. The rest are left on their own, to try to obtain the house by relying on self-help practice, building the house in stages, as they save the money for materials.

2.3.5. FORMER YUGOSLAV REPUBLIC OF MACEDONIA

Overview: FYR of Macedonia is the most southern of all the countries of former Yugoslavia. It borders FR Yugoslavia in the North, Bulgaria in the East, Greece in the South and Albania in the West. The climate is continental and the hottest month is July, with average temperature of 25'C, and the coldest is January with average temperature of -3'C. It is also a seismically unstable area.[17] According to the 1994 census, the total population of the country is 1,95 million, with the capital Skopje having 403,000 inhabitants.

Even during the existence of SFR Yugoslavia, Macedonia was the poorest republic. After gaining independence in the fall of 1991, Macedonia faced massive economic difficulties including the annual inflation rate which rose to 2000% in 1992, and external pressures due to the sanctions imposed by UN against FR Yugoslavia, which broke marketing and supply channels with Serbia and Montenegro. There was also the Greek blockade over the name dispute. However, due to stabilization programs in place, and help from

[17] The big earthquake of 6 degrees on Richter scale virtually destroyed Skopje, the capital, in 1963, when 1200 people were killed, and 170,000 left homeless. This event very much influenced the revision of building codes in whole former Yugoslavia.

IMF. the Macedonian economy is recovering and the inflation rate in 1997 was down to a controllable 8%. while the gross domestic product per head reached USS 2.263. The privatization program has shown good significant progress during 1995 and 1996, resulting in the World Bank's promise to advance up to USS 300 million to the country over the next three years. with the major part being designated to support small-scale private-sector development. Still. the unemployment rate is very high: by 1996 it had reached 50%. although many people registered as unemployed in fact make some kind of income by farming or black-marketeering.

Housing conditions: The level of urbanization in FRY of Macedonia is 59%. According to the 1991 census. 78% of the total number of dwellings was owner occupied. but it is assumed that this number is higher today. since the privatization of socially-owned rental units. The average number of people per dwelling unit is 3.7. with 19.1 m^2 of useful floor space per person.

Housing market: Construction accounted for 4.7% of the GDP in 1996. Housing construction is dominated by the private sector. which builds around 90% of all new houses. However. due to the economic instability and widespread poverty. the rate of new construction in housing is declining every year. In 1996. only 485 residential units were completed. compared to 999 completed in 1995. and 2.465 units in 1991. The main carriers of the job are small-scale construction companies which were able to spring up throughout Macedonia once the restrictions on private enterprises were removed. House prices are similar to those in other countries of the former Yugoslavia. and. there are no adequate financial programs from the banks or government agencies which would help the potential buyers.

2.4. EXISTING BUILDING METHOD

Dwelling units in urban areas in the COFY are built with better quality materials with infrastructure and services comparable to western standards. but they are smaller in size, as opposed to units in rural areas. Average useful floor space was constantly growing over the years: from 12.2 m^2 per person in 1971, to 21.9 m^2 per person in 1987, but there were significant differences between the republics, due to the level of economical and industrial development. Table 1 presents the most recent data of average useful floor space per person in the COFY, which is still among the lowest in Europe.

COUNTRY	Average size of household	Average floor area per person (m^2)	Average size of dwelling unit (m^2)
Slovenia	3.1	32.6	103.1
Croatia	3.2	22.1	70.7
Bosnia and Herzegovina	-	-	-
FR Yugoslavia	3.4	20.0	68.0
FYRO Macedonia	3.7	19.2	70.9

- Data not available.

Table 2.3: Average size of household, useful floor area per person and size of dwelling unit.
Source: Annual bulletin of housing and construction statistics for Europe, 1996.

The home-building industry in the COFY is at a semi-industrialized and semi-prefabricated level. The measuring system in use is metric. There is also modular system; the basic module is 1M which is equal to 10 cm, and derived values: designing and structural module of 6M (i.e. 60 cm), and 3M (i.e. 30 cm). The whole home-building industry and the production of materials and components is based on this premise, so the products from different manufacturers are equally compatible. The main building system for the housing in the COFY is masonry in combination with reinforced concrete. Structural walls are built using hollow brick blocks measuring 19 X 19 X 29 cm, with reinforced concrete piles in the corners and intersection of the walls. Partition walls are built of hollow bricks, as well. Horizontal structures are either reinforced concrete slabs made on site, or semi-prefabricated stem construction with perforated clay blocks as an infilling. Foundations, as well as basement walls are also made of reinforced concrete.[18] The roof structure is

[18] Almost the entire territory of former Yugoslavia is seismically unstable, and the building code is very strict about that. Even in a self-help building activities, people are cautious about that.

made from wood, also on site. Although available on the market, industrially made roof trusses are not in common use because of their high price. The roof is covered with the clay roof tiles.[19]

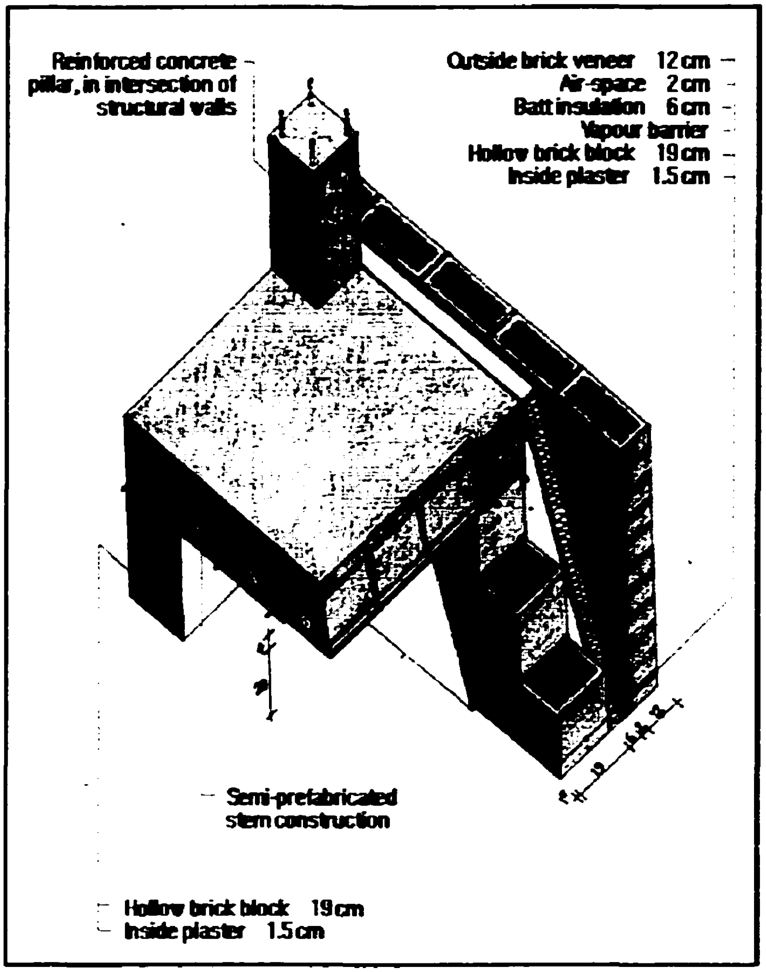

Figure 2.5: Section through the structure of the typical single family house (the right side shows what the building codes require, and the left side what is usually done).
Source: Drawing by author, 1997.

The building codes in the COFY also regulate energy efficiency requirements, some of which are insulation, vapour barrier, and double glazed windows. It is obvious that a wall made of perforated clay blocks is not very efficient, and 6 to 8 cm of insulation on the outer side of the wall is required for the mainly continental Yugoslav climate. But, this is

[19] Recently, the bitumen shingles were introduced (and they are known by the name that Italian exporter gave them: 'Tegola Canadese' - Canadian shingles), but they are still not commonly accepted because of their high price.

something that is not always done. In order to reduce initial costs, and not fully understanding the importance of thermal protection, most of the future homeowners, relying on their own labour and finances when building their own homes, are tend to skip this feature. Also, to build a perfectly precise opening in the masonry wall so the modular window available on the market can fit perfectly is not an easy task even for a highly skilled bricklayer. The craftsmen that can be hired on the 'black market' are not always skilled, so the leakage and the thermal losses that occur are extremely significant.

The main shortcoming of this building technology is construction time. It takes 18 months, on average, to complete the house (turn-key projects). When future home-owners rely on their own financing and labour, it takes even longer because they usually build the house in stages, progressing to the next step when they have saved enough money for materials. As the home-building industry does not offer any alternative options in terms of

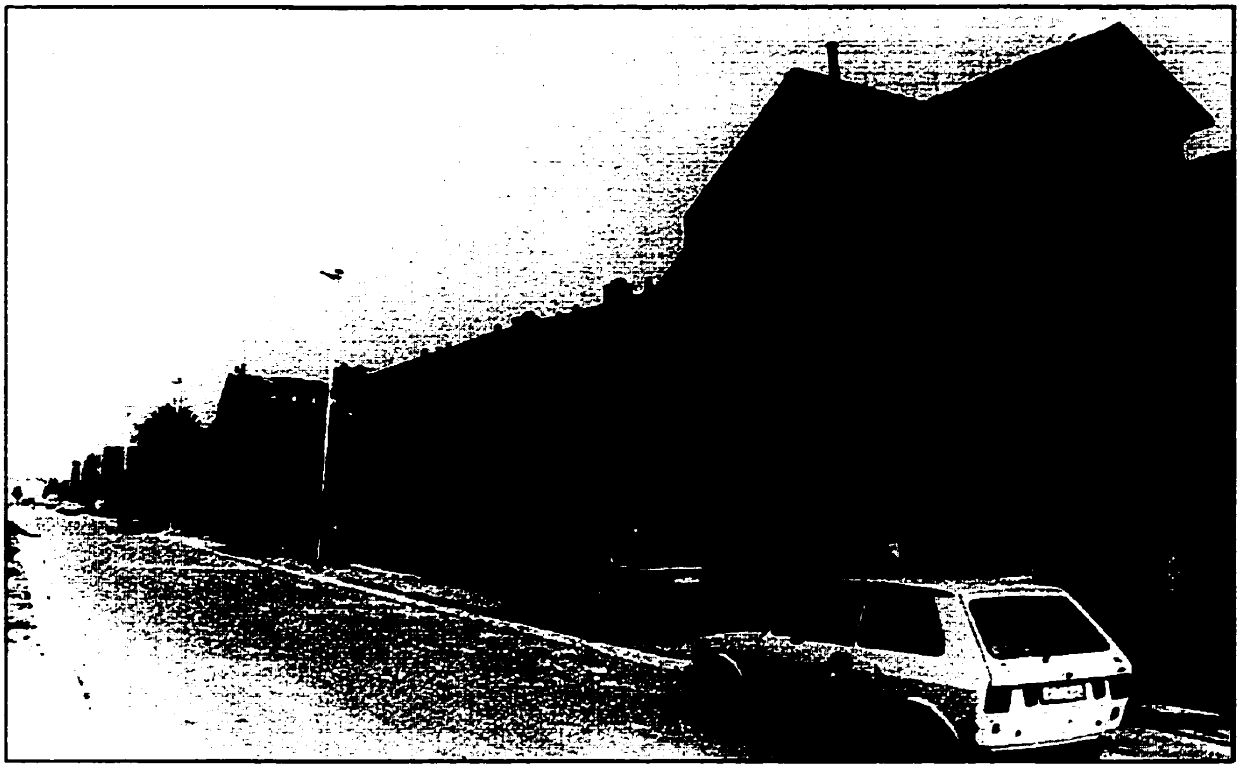

Figure 2.6: New development Bezanijska Kosa in Belgrade, FR Yugoslavia. Extremely high prices of houses makes them unaffordable for median income group.
Source: Photograph by author.

materials and components, even the construction companies which used to build with pre-fabricated components (usually in large-scale apartment building developments), reverted back to this less advanced, "traditional" method. This, of course, significantly effects the price of the house. Even though labour in the countries of former Yugoslavia is on average 8 - 10 times cheaper than Canadian labour, extended construction time increase the labour portion to 40 - 45 % of the total construction costs.

The average price of the house in turn-key projects in the COFY is DM 800 - 1200 per m^2 (Can$ 70 - 105 per sq. ft.), without the land. The reasons for this include extended construction time, and unreasonably high prices of building materials, components and other expenses connected with the construction. In declining market, every involved part is building up their price in order to make profit. On the other hand, weaker economies and weaker purchasing power of the population results in lower investments in new housing, regardless of existing shortages. Table 2.4 presents the average annual income in the countries of former Yugoslavia compared to the median price of the house. It is easy to conclude that without adequate financial programs it is almost impossible for average people to solve their housing problems. But, with the exception of Slovenia, such programs do not exist in any one of the newly established countries of the former Yugoslavia.

COUNTRY	Median price of the house (land excluded) (US $)	Median annual income (US $)	Ratio between annual income and price of the house	Existance of financing assistance programs
Slovenia	87,600	7,277	12	Yes
Croatia	97,000	4,260	23	No
Bosnia and Herzegovina	-	1,890 525*	-	No
FR Yugoslavia	70,000	1,080	65	No
FYRO Macedonia	-	-	-	No

- Data not available.
* Annual income in Republica Srpska.

Table 2.4: Disparity between the median price of the house and median annual income in the countries of former Yugoslavia.
Sources: UN Statistics, World Bank statistics, 1997

2.5. SUMMARY AND CONCLUSION

There are many similarities between the situations in the COFY:

- Serious housing shortages: The younger members of the urban population, employees in health-care, education, and other tertiary activities, and those in the lower and lower-middle classes were the groups which have always been affected by the problems of obtaining a dwelling unit. This group is augmented the high number of refugees, and with the disappearance of publicly built rental units, which used to account up to 35 % of newly built units per year.
- High house prices: from US\$ 500 - 750 per m^2 in FR Yugoslavia to US\$ 1.115 per m^2 in Croatia.
- Weak economies, high levels of unemployment and the decreased purchasing power of the population results in widespread poverty. The ratio between median price of the house and median annual income is extremely high (table 2). For example, in FR Yugoslavia it takes 65 times an average annual wage to buy an average priced house.
- The lack of financial programs from banks or government agencies to help both builders and prosperous buyers. The only country which offers financial help is Slovenia, which has the most stable and growing economy of all countries of Central and Eastern Europe. In the others, cash payment have become the base for financing home construction.
- The shift in the types of housing producers: the once powerful large-scale publicly owned construction companies ("enterprises"), are finding it difficult to adapt to a market economy and are now facing insolvency. In contrast: small-scale firms capable of building 2 - 30 homes per year, managed by former employees of the "enterprises", are emerging strongly in the marketplace. The number of houses built by their owners remain also significant.
- The limited availability of building materials and components forces builders to go

technologically "backward" and return to conventional masonry, which is time consuming and additionally affects already overpriced houses.

- The lack of efficient coordination between builders, designers, banks, municipal governments and other players involved in the process.

Clearly, without introducing any sort of financial incentives, the market for moderately priced housing cannot evolve in any of the countries of the former Yugoslavia. Still, one of the steps that can be taken in order to make the houses more affordable is to look at the technological side of the problem. Introduction of the alternative building systems which can improve the implementation time and therefore reduce the total price of the house is one of the possible solutions. That would also create competition within the local building industry and hopefully influence unrealistically high prices of the materials and components that are currently available in the market. For this reason, this research is attempting to evaluate different building systems developed and produced in Canada, in an effort to discover which ones could be applicable in the market of the COFY. The criteria for evaluation will be presented in the next chapter of this thesis.

CHAPTER 3:
FORMING EVALUATION CRITERIA FOR SELECTION OF BUILDING SYSTEM

3.1. INTRODUCTION

One of the major drawbacks in the home-building industry in the countries of the former Yugoslavia is the existing building system. The limited range of choice of materials and components is forcing builders to build using masonry, a process which is time consuming and therefore, affects the total price of the house. Alternative building systems can help to overcome these obstacles. But, the issue of technology transfer is complex, and involves approaching the subject from several angles. The acceptance of new technology, even the simplest innovation, depends on many aspects, such as implementation, economy, and the cultural and psychological mind-set of the market.

Canadian home-builders and manufacturers of materials and components have been successful in exporting their technology throughout the world, and their experiences have been invaluable in helping the author to study the issue of technology transfer, to recognize key-problems and to incorporate the findings in this research. The thorough and detailed study is needed in order to fully understand the complexity of introducing a new product to a foreign market.

Bearing in mind that this thesis is dealing specifically with the question of selecting an appropriate building system for export which would be readily accepted in the markets of the COFY, in this chapter the author will attempt to develop a proper tool for this task. The tool would be a set of criteria combined with an appropriate evaluation system which could be used to examine the characteristics of several existing building systems, which have been developed and used in Canada, their applicability in the housing industry in the

COFY. and their adaptability to local building codes. The criteria will be classified in three main groups: technical, economic and psychological. The following sub-groups are suggested:

1. TECHNICAL ASPECT:

- Codes and regulations
    - Load bearing capacity
    - Earthquake resistance
    - Fire resistance
    - Energy efficiency
    - Acoustics
- Implementation
    - Construction time
    - Requirements for skilled labour
    - Requirements for specialized equipment and tools
- Adaptability
    - Adaptability to the metric system
- Durability
    - Estimated lifespan of the building

2. ECONOMIC ASPECT

- Construction costs
    - Cost of building materials and components
- Labour costs
    - Labour costs (both Canadian and local)
- Transportation costs
    - Cost of shipping the components and building materials from Canada

3. PSYCHOLOGICAL ASPECT (ACCEPTANCE)

- Homeowners acceptance
  - Reservations about performance of the house
  - Requirements for regular maintenance
- Builders acceptance
  - Availability of materials and components
  - Availability of skilled labour

Throughout the following analysis, different conditions will be presented, and some recommendations will also be made regarding the potential for export of some features of home-building systems developed in Canada to the housing market of the countries of Former Yugoslavia.

3.2. TECHNICAL ASPECT

As was discussed in the previous chapter, the main building materials in the housing industry in the COFY are hollow brick-blocks and reinforced concrete. Even though traditional houses in these parts of the Southern-East Europe were built in different ways, influenced by the availability of local materials, the diversity in climatic conditions, and various influences from the occupation at various times in history by neibouring countries, during the past 50-60 years, the masonry has been used exclusively, and has irreversibly changed the appearance of indigenous housing. Today's housing industry can be characterized as semi-industrial and semi-prefabricated, where the self-help practice (i.e. owner-built homes) plays significant role.

3.2.1. Codes and regulations

The current building codes that exist in the COFY are heirs of unified building codes developed during the years prior to the disintegration of the country, as a part of general standardization codes, called JUS.[20] They were based primarily on the German standardization norms, DIN, with the necessary adjustments being made according to the requirements of local conditions and industry. JUS uses SI measuring system. In architecture, the basic module unit is 1M which is equal to 10 cm, with its derived values: designing and structural module of 6M (i.e. 60 cm), and 3M (i.e. 30 cm). The whole home-building industry and the production of materials and components is based on this premise, so the products from different manufacturers are equally compatible. Any changes in the building codes that were made after the disintegration of the Former Yugoslavia, were made with the aim of unification and coordination with the EU standards.

3.2.1.1. Load-bearing capacity:[21] The houses in the COFY usually have two to three floors, with a basement or semi-basement included. The local building code requires the basement and semi-basement walls to be built of reinforced concrete. Walls above ground are usually built of hollow brick-blocks 19 cm wide, with the proper reinforced concrete pillars reinforcement in the corners and every wall intersection, as well as with tie-beams that connect walls with the horizontal structure. This heavy and solid structure can easily bear any live load that occurs in low-rise housing, so there are no special requirements in this instance, especially in the parts which are seismically stable. The roof structure is usually build of wood, covered with terracotta tiles. The tiles themselves are very heavy and there are additional affects to the roof structure from the weight of snow and the wind influence.

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[20] JUS: Abbr.. of *Jugoslovenski standard* -Yugoslav (standard) norms.

[21] This feature represents the capability of the building system, or its structural sub-components, to carry, hold and transfer the dead load from its own weight, as well as the live load from the furniture, appliances and the people, and the weight of snow and the wind forces for the roof.

Values of live load (p) for residential buildings determined by building codes are:

- for spans up to 4.50 m, p=1.25 KN/m^2,
- for spans between 4.50 and 5.50 m, p=1.50 KN/m^2,
- for spans larger than 5.50 m, p=2.00 KN/m^2,
- for non-habited attics, p=1.25 KN/m^2,
- for cantilevers, balconies and stairs, p=3.00 KN/m^2 *(Privremeni tehnicki propisi, 1948.)*

As all proposed building systems are already used for building low-rise single family houses, it is assumed that they have already proven their capability to fulfill the requirements for loads that occur in these types of structures. For this reason, there is no special criterion in this instance.

3.2.1.2. Earthquake resistance: The diversity in topography and in the age of the mountains makes the region of the COFY seismically unstable. This is the reason why building codes are very strict in terms of earthquake resistance. All constructions are divided into five categories, where category number IV represents temporary buildings whose destruction would not endanger human lives, up to the highest category (buildings of extreme importance), where the construction must not be damaged under any circumstances. Residential buildings, both high and low rise belongs to category II: building can suffer a certain amount of damage from an earthquake, but must not collapse. As was said before, the main building system for the residential structures is masonry, which needs to be additionally supported by reinforced concrete pillars and beams. The calculations for this structure, which includes the amount of steel reinforcement and the quality of concrete, is required part in the process of obtaining the building permit.[22] However in some

[22] The calculations are based on the seismic maps for the recurrent earthquakes for the period of 500 years as well as on the additional parameters which depends on the quality of the ground.

cases, regardless of the building system used, the calculation is not required, but the number of stories is limited to:

- groundfloor + 1 for VIII degree of earthquake (Mercalli scale);
- groundfloor + 2 for VII degree of earthquake (Mercalli scale). *(Pravilnik o tehnickim normativima za izgradnju objekata visokogradnje u seizmickim podrucjima, 1981).*

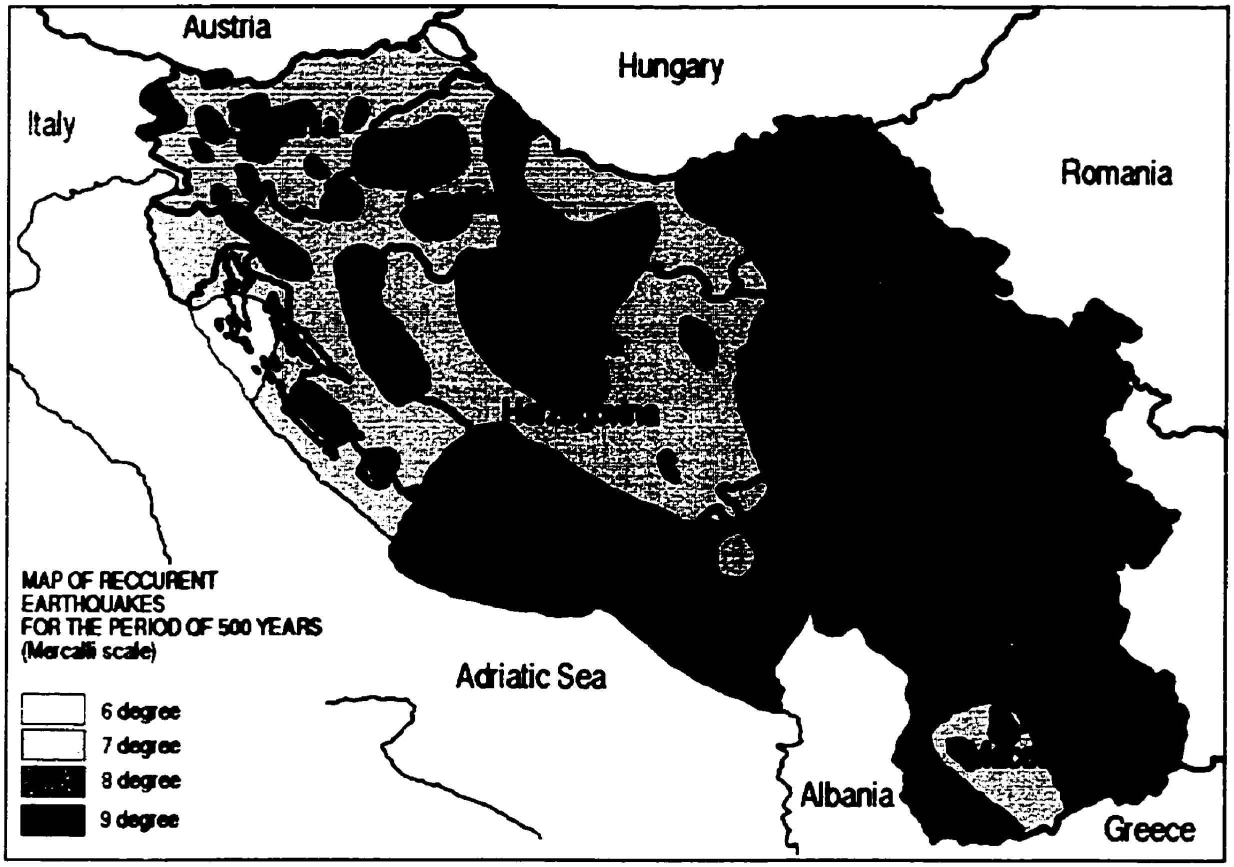

Figure 3.1: The map of recurrent earthquakes for the period of 500 years. This map is relevant for the earthquake resistance of residential buildings.
Source: Pravilnik o tehnickim normativima za izgradnju objekata visokogradnje u seizmickim podrucjima. (1981).

The map presented in figure 3.1 shows the instances of recurrent earthquakes for a period of 500 years, which is used for the calculations regarding residential buildings. It shows that in the major part of the territory of the COFY, there is no need for special features in order to fulfill this requirement. Still, exact information needs to be obtained for the specific location, or if the house already exceeds prescribed size. Therefore, it is recommended that the special requirements for earthquake resistance depend on the location. as well as on the size of the house.

Criterion: No special approval is necessary for the houses of following sizes:

- groundfloor + 1 floor high in VIII degree earthquake zones:
- groundfloor + 2 floor high in VII degree earthquake zones.

3.2.1.3. Fire resistance: Having the tradition of building in brick-blocks and reinforced concrete, materials that by nature, are less inflammable, building codes in the COFY have different demands than those in Canada. For example, neither fire-alarms, nor sprinkler systems are required for the low-rise houses.

According to building codes, requirements for fire resistance in residential buildings are:

- All structural elements in the building should be made of non-combustible materials and must have a fire-resistance of a minimum of 90 minutes.
- Insulation materials within the walls can be inflammable only if the inside paneling is fire-resistant for the period of a minimum of 90 minutes. Otherwise, the insulation material should be non-inflammable.
- Residential units, if attached to other residential, commercial or other units, should be separated from them by fire walls with a fire-resistance of a minimum of 90 minutes.

However, one should keep in mind that the building of high-rise apartment buildings was favoured for decades, and the existing building codes refers mainly to these kinds of buildings, and allows for certain concessions in the cases of single family low-rise houses *(Uslovi, 1983)*. In this case, the most important requirement is following:

Criterion: No requirements for within one unit. Attached units must be separated by fire walls with a fire-resistance of a minimum of 90 minutes.

3.2.1.4. Energy efficiency: Since the 1970's energy crisis, it has been recognized that proper insulation in a building is an important aspect of every structure. Energy efficiency is a feature that has a direct impact on the indoor environment, energy consumption and cost effectiveness.

The territory of the Balkan peninsula, although not large in size, has characteristics of several climatic types, mostly due to topographical diversities. A mild Mediterranean climate prevails on the sea shore, just a few dozen kilometers away from the severe continental climate in the Alps in the North-West, or the Dinaric mountains in the center, as well as the windy Panonnia lowlands in the North-East. This, of course, influences the part of the building code that deals with energy efficiency requirements for the design and the production of the buildings. The entire territory is divided into a three 'construction climatic zones' *(JUS U.J5.600, 1987)*. Each of them can also be distinguished in every one of the newly established countries.

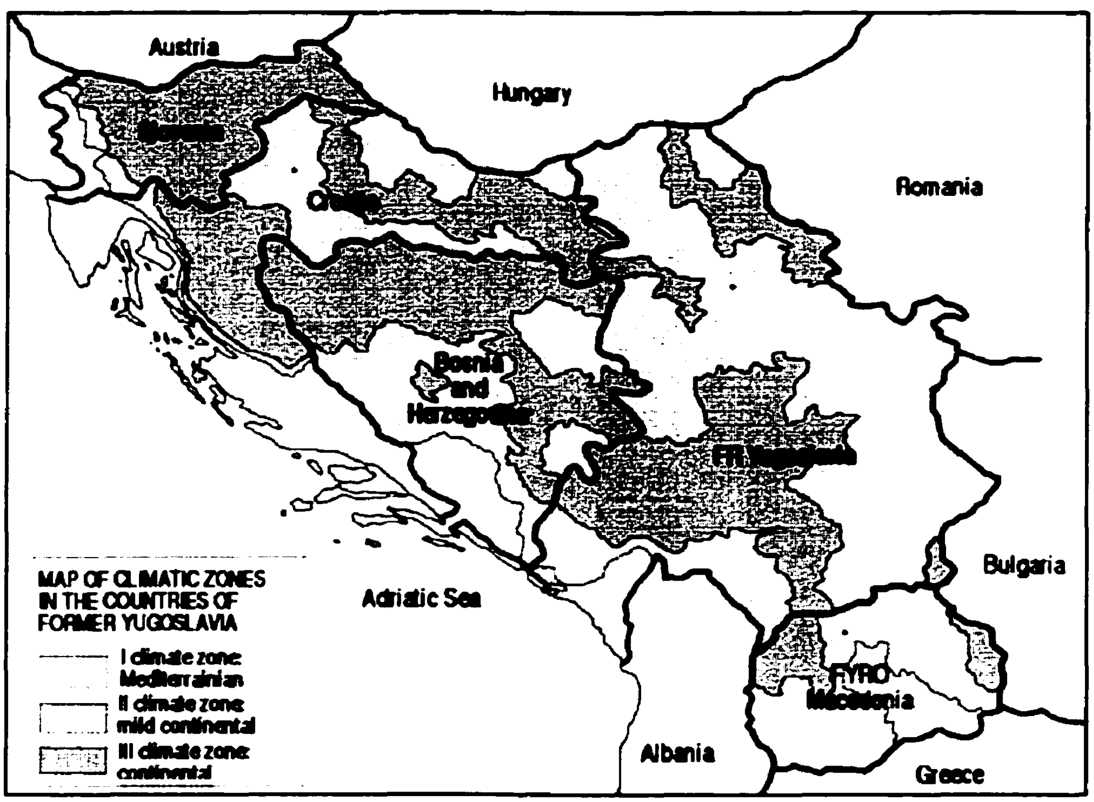

Figure 3.2: The map of construction climatic zones of the countries of former Yugoslavia which are in use for energy efficiency requirements.
Source: Yugoslav building code: JUS U.J5.600, 1987.

Insulation requirements are defined by the *coefficient of thermal conductivity* (k) and the *thermal resistivity* (R), which is in Canada called RSI (the metric equivalent of the imperial R-value)[23]. The value of the coefficient of thermal conductivity (k) of observed structure, calculated according to a code JUS U.J5.510 or measured according to codes JUS U.J5.060 and JUS U.J5.062 cannot be higher and thermal resistivity (R) cannot be lower than the values in the table. (*Toplotna tehnika u gradjevinarstvu: tehnicki uslovi za projektovanje i gradjenje zgrada, JUS. U.J5.600.* ,1987)[24]

ITEM	Construction climatic zones					
	I		II		III	
	k	RSI	k	RSI	k	RSI
1. Outer walls and walls between heated and unheated space	1.20	0.66	0.90	0.94	0.80	1.08
2. Partition wall between apartments and wall between apartment and heated common space	1.95	0.26	1.85	0.29	1.60	0.38
3. Underground outer walls	1.20	0.66	0.90	0.94	0.80	1.08
4. Horizontal slab between apartments	1.35	0.49	1.35	0.49	1.35	0.49
5. Slab on grade	0.90	0.94	0.75	1.17	0.65	1.37
6. Horizontal slab under the nonhabitable attic	0.95	0.88	0.80	1.08	0.70	1.26
7. Horizontal slab above the unheated basement	0.75	1.04	0.60	1.38	0.50	1.71
8. Horizontal slab above the open spaces	0.50	1.79	0.45	2.01	0.40	2.29
9. Flat roofs or slope roofs with heated space under	0.75	1.16	0.65	1.37	0.55	1.65

I climatic zone: Mediterranean;
II climatic zone: mild continental;
III climatic zone: continental.

Table 3.1: Values of the thermal conductivity coefficient (k), and the thermal resistivity (R = RSI) for different structures in different climate zones.
Source: Toplotna tehnika u gradjevinarstvu: tehnicki uslovi za projektovanje i gradjenje zgrada. JUS. U.J5.600. (1987).

[23] RSI 1 = 5.679 R
[24] Thermal resistivity (R) in this text, is adequate to RSI in Canada.

The differences between the required R factor for the different climatic zones will call for additional information for a specific region. Therefore, the most successful building systems that can be used universally in the region of the COFY would be those which allow adjustments to enable them to meet the local requirements.

Criterion: According to climatic zones (I, II, III), required RSI values are:

- for outside walls: 0.66, 0.94, 1.08.
- for roof: 1.16, 1.37, 1.65.

3.2.1.5. Acoustics: Similar to the fire-resistance aspect, acoustic requirements in residential buildings are more applicable to the high-rise apartment buildings and to the reduction of the outside noise and the noise between attached units. The density of the masonry can easily achieve a satisfactory level of noise reduction, so noise reduction was never a serious concern. In low-rise housing, there are no special criteria concerning the level of noise between the rooms within one unit. However, in the case of grouped residential units (e.g. semi-detached houses, row houses, duplexes, triplexes), there are requirements for reduction of noise between the units, defined by minimum soundproofing R_W (dB) of 52 dB *(JUS. U.J6.201. 1989)*. Therefore, the requirement for the soundproofing criterion would be the ability of the building system to allow an additional soundproof barrier in specific cases.

Criterion: No requirements for within one unit. Attached units need to be separated by walls which are able to achieve minimum soundproofing of 52 dB.

3.2.2. Implementation

3.2.2.1. Construction time: Construction time is certainly one of the most important factors which directly affects the cost of labour and, ultimately, the total cost of the house, as well as construction efficiency in general, particularly considering the inflation that exists in every one of the new countries.

Length of construction time is probably one of the weakest aspects of housing production in the COFY. Existing conventional building system, inexpensive labour, self-help practice, and lack of sufficient means for completing the building uninterruptedly, are the factors that can extend the construction time to an average of 18 months. Good organization of the building process, along with an adequate building system could significantly minimize this drawback.

Construction time can be divided according to two main processes: the time needed to realize the rough construction work (e.g. foundation, walls, floors, roof, and all partitions), and the time needed to carry out finishing and installation (i.g. plumbing, electricity, heating). Different building systems perform differently in each of these categories, but in general, the second one is more time consuming. Also, the construction time depends on whether the building system is conventional, semi-prefabricated or prefabricated in its character. Therefore, the implementation time can be separated into:

- the time needed for the rough construction work: execution of this part of the building process using conventional way of masonry in ideal conditions, takes a period of minimum of six weeks.
- the time for finishing and installation of equipment: Bearing in mind that several different professionals and teams need to be involved in this process, efficient execution greatly depends on good organization of work and the possibility of overlapping different types of work which could be done at the same time. This also depends on the type of building system itself (i.e. whether the structural walls surfaces are ready for the final finishing or need drywall or any other kind of internal or external substructure).

Assuming that there is good and efficient organization of work, and a sufficient supply of building materials and components, the house built using masonry can be completed in an average time of 5 months. Therefore, in order to be competitive, newly introduced building systems should be able to reduce this time.

Criterion: The potential for a house to be completed in less than 20 weeks.

3.2.2.2. The requirements for specialized skilled labour:[25] This feature can also be an obstacle to the successful implementation of any building system introduced to a new market. Highly specialized labour could be imported from Canada, but this would increase costs since the labour in the COFY is in general much more inexpensive. Local construction workers could be trained for the job, but this would require additional time. For example, skilled carpenters are available, but they are mostly specialized for the building of roof structures. Additional training would be needed in order to enable them to work with wood-frame structures.

Criterion: For immediate and efficient implementation, the building system should not require specialized skilled labour which is not available locally.

3.2.2.3. Requirements for specialized equipment and tools: As in the previous example, the usage of specialized equipment and tools would need either highly skilled imported labour or training for local workers. It can also effect the cost of construction, because of the amortization factor, and because of its impact on the flexibility of the organization, continuity and efficiency of the work. Also, the potential for later renovation or adaptation of the house might be reduced if those tools are no longer available.

This factor can be important, bearing in mind that recently, main housing producers

[25] This term refers to labour skilled in other than masonry or work with reinforced concrete.

in the COFY are now small construction companies with less than 10 employees, and independent skilled tradesmen who are hired directly by the future homeowner. For them, the obtaining of specialized tools such as concrete pumps or per-vibrators is not possible.

Criterion: The building system should not require utilization of specialized equipment and tools other than those already available in the local home-building industry.

3.2.3. Adaptability

3.2.3.1. Adaptability of building systems to metric measurements: One of the major obstacles in technology transfer is the difference between measuring systems. Even in cases when the complete house, with all its components, is shipped from Canada and installed on site, the issue of different measurements can influence the post occupancy changes in the house. As in the rest of the Europe, the metric system is in use in the COFY, and the whole home-building industry is based on it, and on the modular system where 1M (module) is equal to 10 cm, and derived structural and design intervals of 3M and 6M (i.e. 30 cm and 60 cm).

In order to be compatible with this modular system and, thus with other products from local building industries, new building systems should be adaptable to the metric system. Also, if it can rely on supplies from local existing assortment of materials or components, it would have an advantage in immediate application.

Criterion: Adaptability of the building system to the metric measuring system in order to be compatible with other products of the local home-building industry.

3.2.4. Durability

3.2.4.1. Estimated lifespan of the building: Besides the purely technical aspect, this feature has an equally economic and even psychological perspective. Unlike Canada and

United States, where the house is perceived as a product which can be replaced if circumstances change, in the COFY people still have a notion of building a house not just for themselves but for their descendants. This idea can be supported by the fact that the usual lifespan estimate for a house built using masonry is 100 years. For this reason, it is preferable to this market to have houses with longer estimated lifespans. The higher initial cost, extended over the longer lifetime of the house, actually provides the best value for its buyers. Since the house will probably stay in the possession of one family for a much longer time than in North American countries, it will probably sustain some changes that will reflect the changes in the family. A newly introduced building system should allow for these kinds of changes, with lower costs and with readily available materials. Still, to be competitive with existing masonry, it needs to offer at least a similar estimated lifespan of the house.

Criterion: Houses built with the new building system should have an expected lifespan of 100 years.

3.3. ECONOMIC ASPECTS

The price of a product is the factor which can greatly influence its success or failure in the market place. Being the major investment in the average peoples lifetime, it is understandable that the price of the house is so important.

There are many factors that influence the total price of the house. Beside the construction costs, there is the price of land, infrastructure and services, taxes, and the general economy of the region, which influences investments and interest rates. To take them all into a consideration and make accurate calculations could be the subject for a separate study. That is why the author will focus only on the rough assessment of cost of building materials and components, labour and transportation. Still, it is difficult to compare the exact cost, because a large percentage of low-rise family houses in the COFY are owner-built, where is almost impossible to keep track of money spent on construction. Also, there is a possibility of reducing the cost of Canadian building systems by using local labour, and reducing transportation costs by using local suppliers for some components. For this reason, the assessment of the economic aspect will be divided into sub-levels, where the entries will be analyzed in order to estimate the final price, which, finally, will be compared with the average price of the house in COFY.

3.3.1. Construction cost

According to the latest information (February 1998), the average price of the house in COFY, excluding owner-built homes, is around 750 to 1100 Can$/m^2 (70 - 105 Can$ per sq. ft.) in turn-key projects, depending on the quality of finishing and equipment and on the complexity of the building. This price does not include the cost of land and infrastructure, because in most cases, the future owner buys the lot prior to hiring the construction company to build his house. Naturally, the price of infrastructure, property taxes and other costs should be added to this price. Therefore, the aforementioned price can be considered as the construction price.

3.3.1.1. Cost of building materials and components: Of the construction price of a house which is 750 - 1100 Can$/m^2, the price of materials and components portion is usually between 50 - 60 %. A simple calculation will show that the average total cost for the materials and components can be between 325 - 650 Can$/m^2, which is comparable to prices in Canada.[26] It is easy to conclude that the price is quite high, considering the level of industrialization of the local building industries, but the lack of adequate competition

[26] The average cost for materials and components for Canadian wood-frame houses is around 40 Can$/sq. ft, which is equal to 430 Can$/m^2.

allows the manufacturers to raise the prices beyond reasonable limits. This opens up the possibility for Canadian housing exporters to enter the market of the COFY if they can match above mentioned price with their good quality products.

Criterion: Costs of building materials and components should match the existing local prices which are 325 - 650 Can$/m^2 (30 - 60 Can$/sq. ft.).

3.3.2. Labour costs

The cost of labour is another factor that can very much influence the total price of a house. One of the substantial differences between the Canadian home-building industry and those in the COFY is the price of labour. In Canada, this price is high: between $12 and $30 per hour, and the whole building process is adapted to reduce the number of on site working hours, by shifting the manufacturing process to the factories as much as possible. In contrast, in the COFY, the labour is inexpensive, which reflects on the building process itself by producing extended construction time and slow improvement in industrialization of building industry.

3.3.2.1. Labour cost (both Canadian and local): The cost of labour in the construction industry in the COFY is significantly lower compared to that in Canada. The average wage for the skilled mason is between 35 and 45 Can$ per day, and for his semi-qualified apprentice is around 22 to 27 Can$ per day, which is in total 4 to 5 times less than the wage of Canadian labour.[27] Still, the prolonged construction time due to existing masonry building system and sometimes inefficient usage of labour, augments this price, so the labour portion of total construction costs can be up to 40 - 50 %. With the adequate building system which has reduced construction time and the introduction of Canadian work

[27] This price is for those who work for small scale contractors, which means that they are employed only during the building season. Construction workers who are employees of large state-owned companies are paid an annual salary, but their wages are significantly lower.

organization and standards, the engagement of local labour can significantly influence the total construction cost of a house, and make it more affordable for the local market.

It is almost impossible to provide exact labour cost which contribute to the total cost of a house, because it depends on many factors. A detailed study would be required for each individual case of different building system, in order to determine the share of Canadian and local labour involved in the process. Still, a general estimate can be made of the total labour cost.

Criterion: In order to be competitive with the price of the houses on the market of the COFY, the price of labour (both local and Canadian) involved in the construction should not exceed the 30 % of the total construction costs (i.e. 225 - 330 CanS/m^2).

3.3.3. Transportation costs

3.3.3.1. Costs of shipping the components and building materials from Canada: This item can greatly influence the total cost of a house. The option of shipping the components and building materials from Canada to the COFY is feasible only when there is the certainty of building a large number of houses. Still, in that case, the possibility of shifting the production of at least some components in the local factories would reduce the cost, considering the prices of local labour and raw materials.

Research conducted among the Canadian companies which export their houses overseas, gave the author a general idea of transportation costs.[28] Even though it depends on many factors, it is safe to conclude that shipping would be feasible if the transportation cost do not exceed the 10% of the total construction cost of the house.

Criterion: Transportation cost should not exceed 70 - 100 CanS/m^2 (6.5 - 9.2 CanS/sq.ft.).

[28] For example: Multigon is the company which exports their houses worldwide as a package. The transportation cost depends on the size of the package, but usually it is possible to fit the two house packages in three shipping containers. The average price for one container is 4000 CanS. That price needs to be enlarged by the additional cost of transportation from the port to the site.

3.4. PSYCHOLOGICAL ASPECT

For every new product in the market, as well as in the case of technology transfer, the issue of acceptance is crucial. As was mentioned earlier, the home-building industry is one area where the conservatism is very much a factor. That greatly affects the introduction of a new building method, even one which can bring obvious advantages. One of the reasons for this is of psychological nature: people have a cultural mind-set about the way their houses should look and what they should be made of. New materials and methods are especially unappealing for the cultures where the owner-built homes play a significant role, because professionals needs to be involved in introducing the innovations. Although not everybody builds their own houses in the COFY, the majority still shows a high level of prejudice against new materials and techniques. The most frequent of these prejudices are related to new structural materials and finishes, which directly affect the appearance and the performance of the house.

All participants in the process show certain reservations toward new housing technology: builders and developers as well as the potential buyers. However, the reasons for their reservations are of a completely different nature, which is why the issue of acceptance will be viewed from the points of view of both homeowners and builders. As opposed to the technical and economic aspects, which can be expressed in numerical values, and thus, are easily comparable, the psychological aspect is more of a descriptive nature, and thus, criteria will be presented accordingly.

3.4.1. Homebuyers acceptance

3.4.1.1. Reservations toward performance of the house:[29] For a great majority of people, buying a house is the biggest investment of their lifetime, so it is natural that they will be extremely cautious in their decisions. The cultural mind-set plays a large part in defining their expectations about the house. For example, in cultures where building houses in hard materials, (e.g. bricks and concrete), have a strong tradition, accepting any kind of "lighter" structure might be a problem, because in average people's minds it cannot be compared with the solidity of concrete. For them, the "lighter" structure, such as any sort of frame construction, is equivalent to a temporary structures, and appear "less valuable" than masonry. A house, on the contrary, symbolizes personal asylum, family nucleus, and status, and it needs to "last forever". Overcoming this cultural mind-set is not a simple task.

An average user of any other product is not interested of how that product is made, as long as it offers the expected (or better) performance. There should not be any difference in terms of a house, because it is a product like any other, and despite its complexity, it is not much different than a car, for example. As long as the newly built house performs to its owner's expectations, the question of building method should not be a problem.

The design of the house should preferably be adapted according to the needs and the way of life of the people in the COFY. It also needs to have an appearance that will be in accordance with cultural expectations. Finally, it should achieve at least the same level of comfort, in terms of energy efficiency and sound-proofing as the existing building system. All of these features depend more on other elements rather than on the structural system itself. Different types of applied finishes can greatly determine previously described features.

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[29] The term "performance" here represents the performance of the product as a whole, designed in a certain way and assembled out of different components and materials that work together. It can range from structural issues, such as earthquake resistance, to the sound-proofing of partitions, as well as the durability of the applied finishes.

Criterion: In order to achieve the required appearance and performance of the house. the newly introduced building system should be easily adaptable to design and finishes that are preferable for homebuyers in the countries of the former Yugoslavia.

3.4.1.2. Requirements for regular maintenance: In order to last a long time. and perform well. every house needs regular maintenance such as painting. upkeep of floor surfaces or other minor repairs. The level of this regular maintenance can affect the users satisfaction with the house: the less work needed and the more simple it is for the home-owners to do it by themselves. adds to its appeal. Having the tradition of living in houses built of durable. long-lasting materials which do not require any specialized maintenance except those listed above. as well as the customary "do-it-yourself" practice. has enabled the average homeowners in the COFY to rely on their own efforts for regular maintenance of the house.

Accordingly. in order to be accepted. any newly introduced building system should allow easy regular maintenance. with the materials and tools tnat are available on the current local market.

Criterion: Regular maintenance should be within the self-help ability of the average home-owner.

3.4.2. Builders acceptance

Builders and developers can also show a significant degree of inertia in introducing a new technology into the home-building process. The main reason for this is the great risk involved. along with the enormous investments: builders often fear that houses built using a newly introduced system would not be accepted and thus. would not find buyers. Furthermore. introducing the new building system usually means additional investments in new materials. tools. and adequate labour training. However. if the new building system brings obvious advantages in term of quality, improved efficiency, time saving and reducing costs, builders need to find a way to approach the potential buyers, and to win them over by offering them what they want. Assuming that they are able to fulfill previous criterion (i. e. to offer adequate design and finishes that would influence the appearance and performance of the house), and thus, satisfy future buyers' preferences, builders also need to be able to rely on availability of materials and components as well as skilled labour.

3.4.2.1. Availability of materials and components: This feature is important not only for the efficient execution of construction, but also for the successful post-occupancy life of the house, in terms of future renovations, adaptation due to changed needs of the occupants, or for simple regular maintenance. Regardless of whether materials or components of the new building system would be shipped wholly from Canada, or partly or entirely produced in factories in the COFY, it is very important that these are available on the market, or at least made in a way that is compatible and replaceable with adequate components from the local home-building industry.[30] As was mentioned earlier, adapting to the metric measuring system is one way to bring closer the new building system to components available in local building industry. However, if a building system itself involves materials and components available on the local market (i.g. concrete over steel frame studs) it would significantly improve chances for both implementation and builders' acceptance.

Criterion: A building system that includes materials and components available on local markets would have an advantage over the others.

[30] One of the drawbacks concerning the availability of products and components in the home-building industry in the COFY is the divided and scattered market: there are no big construction stores such as "Home Depot", "Home Hardware" or "Reno Depot", where the manufacturers can present their products and the consumers can find what they need. Developers and consumers need to shop around among many small suppliers or contact the manufacturers directly in order to find adequate products and best prices. For a longer term goal, the opportunity of opening similar chain-stores would surely upgrade the number of possibilities, both for the producers and builders, as well as for the consumers.

3.4.2.2. Availability of skilled labour: The general experience of construction workers in the COFY is with masonry and with concrete. As was mentioned before, skilled carpenters are specialized in the construction of roof structures, which are usually made of raw timber, because prefabricated trusses manufactured in those parts are still too expensive to be used in the construction of average housing. They are also needed for making the formwork for reinforced concrete structural elements. Besides that, there is large number of semi-qualified and unskilled labourers, who are hired as "casual" labour, especially in the "self-help" portion of the private sector. Their experience does not exceed physical work such as digging, reloading and simple masonry. This leads to the conclusion that for any building system which is not based on the principle of pour-in-place concrete, masonry or a combination of these, there will be a need for the specialized training of workers, unless the assembly process is simple and easy to perform.

Criterion: The potential for a building system to employ available and inexpensive local labour with minimum of specialized training.

3.5. SUMMARY

The set of criteria developed in this chapter is intended to review several building systems for low-rise housing, which were developed and produced in Canada, in order to conclude which ones are applicable in the housing market of the countries of the Former Yugoslavia. Three main aspects of the building systems will be reviewed: technical, economic and psychological.

After closely examining the criteria, the following table was developed in order to present the evaluation in the clearest possible way. The findings will point out which of them are most appropriate for immediate implementation.

CRITERION	Comments and recommendations	Mark
3.2. TECHNICAL ASPECTS		
3.2.1. CODES AND REGULATIONS		
3.2.1.1. *Load-bearing capacity:* no specific requirements		
3.2.1.2. *Earthquake resistance*: no special approval necessary for the houses: - groundfloor+1 floor for VIII degree zones: - groundfloor+2 floors for VII degree zones.		
3.2.1.3.*Fire resistance:* no requirements for within one unit. Attached units must be separated by fire-walls with a fire-resistance of a minimum of 90 minutes.		
3.2.1.4. *Energy efficiency*: RSI requirements according to climatic zones: - outside walls: 0.66. 0.94. 1.08. - roof: 1.16. 1.37. 1.65.		
3.2.1.5. *Acoustic*: no requirements for within one unit. Attached units need to be separated by walls which are able to achieve minimum soundproofing of 52 dB.		
3.2.2. IMPLEMENTATION		
3.2.2.1. *Construction time*: the potential for house to be completed in less than 20 weeks.		
3.2.2.2. *Requirements for specialised skilled labour:* new building system should not require specialized skilled labour which is not available locally.		
3.2.2.3. *Requirements for specialized tools and equipment:* Building system should not require utilization of specialized equipment and tools. other than those already available within the local home-building industry.		
3.2.3. ADAPTABILITY		
3.2.3.1. *Adaptability of building system to the metric system:* the new building system should be adaptable to the metric measuring system in order to be compatible with other products of the local home-building industry.		

Continue...

3.2.4. DURABILITY		
3.1.5.1.*Estimated life-span of the building:* houses built with the new system should have an expected lifespan of 100 years.		
3.3. ECONOMIC ASPECTS		
3.3.1. CONSTRUCTION COST		
3.3.1.1. *Cost of material and components:* these costs should match the existing local prices of 325 - 650 CanS/m^2 (30 - 60 CanS/sq. ft.).		
3.3.2. LABOUR COST		
3.3.2.1. *Labour cost:* Labour costs (both Canadian and local) should not exceed the amount of 225 - 330 CanS/m^2 (21 - 30 CanS/sq.ft.), or 30% of total cost.		
3.3.3. TRANSPORTATION COST		
3.3.3.1. *Transportation cost:* Transportation cost should not exceed the price of: 70- 100 CanS/m^2 (6.5 - 9.2 CanS/sq. ft.), or 10% of the total cost.		
3.4. PSYCHOLOGICAL ASPECT		
3.4.1. HOMEBUYERS ACCEPTANCE		
3.4.1.1. *Reservations towards performance of the house:* the newly introduced building system should be easily adaptable to design and finishes that are preferable for homebuyers in the COFY.		
3.4.1.2. *Requirements for regular maintenance:* regular maintenance should be within the self-help capability of the average homeowner.		
3.4.2. BUILDERS' ACCEPTANCE		
3.4.2.1. *Availability of materials and components:* building system that involves materials and components available in local markets would have an advantage over the others.		
3.4.2.2. *Availability of skilled labour:* the potential for a building system to employ available and inexpensive local labour with a minimum of specialized training.		

Marks: 2 - Fully satisfy the criterion;
1 - Partly satisfy the criterion, but adjustments are possible;
0 - Do not meet the criterion.

Total points:

CHAPTER 4
EVALUATED BUILDING SYSTEMS

Alternatives to masonry work, which is the major building method for low-rise houses in the COFY, are different kinds of prefabricated and semi-prefabricated structural systems. These systems can significantly reduce the construction time, which is, in general, the weakest point of the existing building system. Being able to adapt to the local modular system opens possibilities of allowing a choice of different products that can be applied, thus satisfying a wide range of market needs (i.e. from lower- to high-income prospective buyers). Several kinds of structural systems, developed and produced in Canada, will be presented and analyzed here: wood-frame and steel-frame based systems, concrete/foam core sandwich panels, plywood/foam core sandwich panels, the permanent insulated formwork/concrete system and the PVC extrusion permanent form/concrete system.

These systems have been selected following thorough research of the Canadian home-building industry. By contacting manufacturers and exporters of building materials and components as well as prefabricated "kit" houses, the author has had a chance to familiarize herself both with the technical characteristics of selected systems and with current trends in housing exportation. All data presented here is obtained from manufacturers' publications, from direct contact with employees or, where possible, from published results of tests performed on components. The author would like to point out as well, that given prices are result of approximations given during conversation. The exact prices of products depend on many factors, and they could be the subject of a separate study. However, these approximations are good enough to offer general picture about the product.

4.1. WOOD-FRAME BASED STRUCTURAL SYSTEMS

The vast majority of low-rise residential buildings in Canada and the United States are built using the wood-frame structural system, which is also in use in Japan, Australia, and other parts of Europe. Actually, wood as a building material in housing can be found throughout the world where its availability and climatic conditions made it effective. Still, in Canada, because of the high level of industrialization and specific climatic conditions, building systems based on wood are developed almost to perfection and they are exported and highly valued for their quality beyond Canada's borders. The post-and-beam building system and Canadian log houses are some of these, but because of their complexity and the price, they will not be included in this study. The focus will be on the 2x6 wood-frame building system, preferably for its advantages and popularity: more than 90% of Canadian home-builders and exporters use this building system.

Figure 4.1: Prefabricated wood-frame houses
Source: Canada's exportable houses, 1994

Figure 4.2: Prefabricated panels do not take too much space in transport.
Source: Courtesy of FERMCO, 1998.

One of the biggest advantages of the wood-frame system lies in the possibility of shifting the greater part of the construction process from the site to the factories, where prefabricated or semi-prefabricated panels are produced. Therefore, the amount of labour needed for assembly is reduced, as is the construction time, which greatly impacts on the total cost of the house. Modular panels can be easily packed and transported, and it is possible to use the same modular unit for various types of houses. The assembly itself is easy and fast: a crew of 6 to 8 workers can erect a house within 5 to 7 days. Light-weight panels do not require special equipment or tools and can be handled by men. Skilled carpenters are available in the COFY because even though the main building system in these countries is masonry, carpenters are used to build wooden roof structures.

The other advantage of a wood-frame structural system is its ability for easy adaptation to specific requirements. For example, the amount of insulation can be easily changed to achieve the R-factor required by local building codes. Also, in areas of seismic instability, while there are several issues that need to be considered, in general, light wood-frame structures, which are properly designed and constructed, perform quite well during earthquakes.[31] Similarly, the requirements for noise reduction can be met by additional improvements.

The price of wood-frame houses can be competitive with the existing prices in the COFY, which is 750 - 1100 Can\$/m^2 (70 - 105 Can\$/sq. ft.). The author obtained the information from several manufacturers who are successfully exporting their package houses (or "kit" houses) in different European countries.[32]

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[31] To avoid sliding off the foundations, the sill plates need to be bolted with 1/2 in. bolts on 4-6 ft. centres. Avoiding large window openings in the seismicaly unstable areas should prevent the torsion problems that might occur during the earthquakes. To reinforce the structure from lateral forces of earthquake, a vertical plywood diaphragm is required, extending from the bolted foundation sill plate to the first floor. Also, partitions should reach the roof rather than stop at the ceiling line, because this way they are utilized as shear walls which can resist lateral forces. All brick or stone veneers as well as brick chimneys must be properly reinforced and anchored to walls to prevent their falling. *(Stratta, 1987)*.

[32] Interhabs Ltd., Halifax, NS; Modulex, Quebec, PQ; Fermco, St-Adelphe, PQ; Multigon, Ste-Anne-des-Lacs, PQ; PRO-FAB, St-Mathieu-de-Beloeil, PQ; Normerica Building Systems Inc., Mississauga, ON.

CRITERION	Comments and recommendations	Mark
3.2. TECHNICAL ASPECTS		
3.2.1. CODES AND REGULATIONS		
3.2.1.1. *Load-bearing capacity:* no specific requirements.	Bearing in mind that this system is already in use for housing, it is assumed that it can easily bear loads common to this type of buildings.	2
3.2.1.2. *Earthquake resistance*: no special approval necessary for the houses: - groundfloor+1 floor for VIII degree zones; - groundfloor+2 floors for VII degree zones.	Some of the features that can improve lateral forces resistance of wood-frame system include inserting vertical diaphragms, extending partition walls to the roof rather than ceiling line, and avoiding large window openings.	1
3.2.1.3.*Fire resistance:* no requirements for within one unit. Attached units must be separated by fire-walls with a fire-resistance of a minimum of 90 minutes.	This system is considered combustible. Masonry fire-walls are required between attached units.	0
3.2.1.4. *Energy efficiency*: RSI requirements according to climatic zones: - outside walls: 0.66, 0.94, 1.08. - roof: 1.16, 1.37, 1.65.	Adjustable, as required. By adjusting the amount of insulation according to requirements, the final costs can be reduced.	2
3.2.1.5. *Acoustic*: no requirements for within one unit. Attached units need to be separated by walls which are able to achieve minimum soundproofing of 52 dB.	Wood-frame system by itself does not act as sound barrier. The required results can be achieved by adding insulation in partition walls, which would increase the costs.	1
3.2.2. IMPLEMENTATION		
3.2.2.1. *Construction time*: the potential for house to be completed in less than 20 weeks.	Prefabricated wood-frame kit houses can be completed within 10 weeks.	2
3.2.2.2. *Requirements for specialised skilled labour:* new building system should not require specialized skilled labour which is not available locally.	Implementation needs highly specialised labour which is not immediately available locally, therefore, local carpenters need to be trained.	0
3.2.2.3. *Requirements for specialized tools and equipment:* Building system should not require utilization of specialized equipment and tools, other than those already available within the local home-building industry.	Light-weight panels can be handled by men, and no special tools are needed for assembly. Other carpentry tools are available in local markets.	2
3.2.3. ADAPTABILITY		
3.2.3.1. *Adaptability of building system to the metric system:* the new building system should be adaptable to the metric measuring system in order to be compatible with other products of the local home-building industry.	Prefabricated wood-frame houses come in the imperial measurement system, thus they are not compatible with other products of the local home-building industry.	0

Continue...

3.2.4. DURABILITY		
3.1.5.1. *Estimated life-span of the building:* houses built with the new system should have an expected lifespan of 100 years.	Good quality wood-frame house with adequate maintenance can have a lifespan comparable to masonry.	1
3.3. ECONOMIC ASPECTS		
3.3.1. CONSTRUCTION COST		
3.3.1.1. *Cost of material and components:* these costs should match the existing local prices of 325 - 650 Can$/m^2 (30 - 60 Can$/sq. ft.).	According to several manufacturers, the price of a prefabricated kit house is around 300 - 450 Can$/m^2.	2
3.3.2. LABOUR COST		
3.3.2.1. *Labour cost:* Labour costs (both Canadian and local) should not exceed the amount of 225 - 330 Can$/m^2 (21 - 30 Can$/sq.ft.), or 30% of total cost.	Reduced construction time greatly affects the labour cost, which can be decreased to 110 - 160 Can$/m^2.	2
3.3.3. TRANSPORTATION COST		
3.3.3.1. *Transportation cost:* Transportation cost should not exceed the price of: 70- 100 Can$/m^2 (6.5 - 9.2 Can$/sq. ft.), or 10% of the total cost.	Approximate transportation cost for wood-frame prefabricated house is Can$ 6,000 to 8,500 per house, which is less than 10% of total costs. (However, this price depends on the quantity of shipping.)	2
3.4. PSYCHOLOGICAL ASPECT		
3.4.1. HOMEBUYERS ACCEPTANCE		
3.4.1.1. *Reservations towards performance of the house:* the newly introduced building system should be easily adaptable to design and finishes that are preferable for homebuyers in the COFY.	The flexibility of wood-frame systems should allow adaptation to any design of the house, as well as to different kinds of internal and external finishing. Once completed, a house does not have to reveal different structural system.	2
3.4.1.2. *Requirements for regular maintenance:* regular maintenance should be within the self-help capability of the average homeowner.	Some maintenance can exceed the "do-it-yourself" maintaining experience of local homeowners. For example, inside finishing (gypsum boards) require more maintenance than plaster used in masonry.	1
3.4.2. BUILDERS' ACCEPTANCE		
3.4.2.1. *Availability of materials and components:* a building system that involve materials and components available in local markets would have an advantage over the others.	Even though some components (e.g. batt insulation, plumbing, piping) are available in local markets, the others, such as gyprock boards, or different kinds of exterior siding are not, and this would create problems for future maintenance and renovations.	0
3.4.2.2. *Availability of skilled labour:* the potential for a building system to employ available and inexpensive local labour with a minimum of specialized training.	Even though there are many skilled carpenters in the local home-building market, the nature of this job is different and some training would be required.	1

Continue...

Marks: 2 - Fully satisfy the criterion;
1 - Partly satisfy the criterion, but adjustments are possible;
0 - Do not meet the criterion.

Total points: 21

Some housing experts argue that wood-frame houses would be rejected in the region where masonry is the dominant building system. However, the system's many advantages can help to overcome any prejudice. Finishing, such as brick veneer, or stucco, for example can be used to achieve a variety of appearances, according to the home-buyers' preferences. This system might not be accepted in the part of the market serviced by self-help practice (which is still significant), but otherwise, the quality and advantages of prefabricated wood-frame houses can slowly be introduced into the market of the countries of former Yugoslavia.

4.2. LIGHT-WEIGHT STEEL FRAME BUILDING SYSTEM

The use of light-weight steel framing for residential buildings is relatively new even in Canada, and not many builders work with this system yet. The author of this thesis has had difficulties finding out information on this topic. Even though there are many manufacturers of steel components (studs, beams and trusses), there are not many builders who build houses, nor enterprises who offer prefabricated steel frame houses as a package. Still, contact with manufacturers and builders, uncovered some valuable information and experiences which will be presented here.

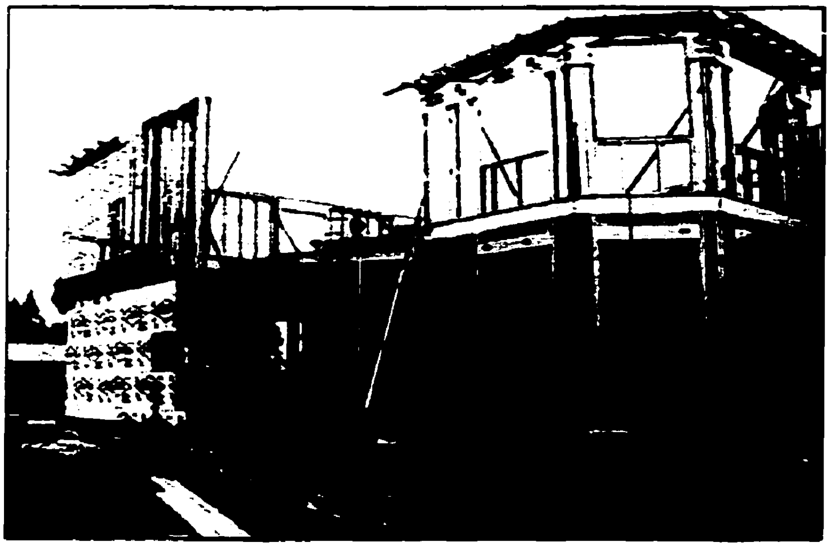

Figure 4.3: Light-weight steel frame houses.
Source: Courtesy of Canadian Sheet Steel Building Institute, 1998.

The basic principles of building with steel are similar to those when building with wood, but steel studs and joists are used instead of wooden ones. The framing is usually done directly on site, according to specifications and designs. Light-weight frames are easily erected by two men. Another process is identical to one used with the wood-frame houses (i.e. placing the insulation, inside and outside finishing). The advantages of steel-frame over wood lay in the strength of the structure, and its durability. There is no twisting, warping, nail-popping or other deviations that can occur with wood over time. Resistant to humidity and insects. the steel-frame structure is extremely durable. Also. it is suitable for seismically unstable areas. Required thermal resistance is achieved by regulating the amount of insulation. Moreover. the steel studs have smaller dimensions than wooden ones. therefore. more insulation can be placed in walls of the same thickness.

According to builder Waine Berry of Metallic Homes. Edmonton. a steel-frame house is about 5 % more expensive than the same house built with a wood-frame (materials only). There are. however. other advantages that can not be overlooked. Light-weight steel studs and joists take about 60% less space than wooden ones. which is very important in terms of savings in transportation costs. Erecting the house is faster. so labour cost less. even though skilled labour is required. There are additional savings on maintenance. and also. the insurance premiums are up to 40% less than for the wood-frame house because this structure is non-combustible.[33]

Light-weight steel framing allows different kinds of inside and outside finishing. so once the house is completed. there is no difference between a traditionally built wood-frame and a steel-frame house. This can certainly help in overcoming the psychological reservations of prosperous home buyers toward a new building system.

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[33] This advantage. actually is not very applicable in the countries of former Yugoslavia at the moment. because masonry is non-combustible material. and people do not need to insure the house for this. Insurance usually include only damage to furniture. appliances and other articles that could be affected in a fire. but not the structure of the house itself.

CRITERION	Comments and recommendations	Mark
3.2. TECHNICAL ASPECTS		
3.2.1. CODES AND REGULATIONS		
3.2.1.1. *Load-bearing capacity:* no specific requirements	The strength of a steel frame can easily bear any load that occurs in residential buildings.	2
3.2.1.2. *Earthquake resistance*: no special approval necessary for the houses: - groundfloor+1 floor for VIII degree zones; - groundfloor+2 floors for VII degree zones.	With adequate adjustments and introduction of vertical diaphragms which will take lateral forces, this building system shows excellent performance in earthquake areas.	2
3.2.1.3.*Fire resistance:* no requirements for within one unit. Attached units must be separated by fire-walls with a fire-resistance of a minimum of 90 minutes.	This system is considered non-combustible. However, masonry fire-walls are required between attached units.	1
3.2.1.4. *Energy efficiency*: RSI requirements according to climatic zones: - outside walls: 0.66, 0.94, 1.08. - roof: 1.16, 1.37, 1.65.	It is possible to adjust the amount of insulation according to requirements. It can bring additional savings, because the required amount of insulation is lower than in Canada.	2
3.2.1.5. *Acoustic*: no requirements for within one unit. Attached units need to be separated by walls which are able to achieve minimum soundproofing of 52 dB.	The system itself does not offer acoustic comfort. This can be achieved with additional features (e.g. a masonry fire wall between the attached units can act as noise reduction wall).	1
3.2.2. IMPLEMENTATION		
3.2.2.1. *Construction time*: the potential for house to be completed in less than 20 weeks.	According to the builders, the light-steel house can be finished in 12 to 14 weeks.	2
3.2.2.2. *Requirements for specialised skilled labour:* new building system should not require specialized skilled labour which is not available locally.	The implementation requires highly skilled labour (velders), which are not immediately available.	0
3.2.2.3. *Requirements for specialized tools and equipment:* Building system should not require utilization of specialized equipment and tools, other than those already available within the local home-building industry.	Light-weight frames can be handled by men. Still, specialized tools are required for assembling a house.	1
3.2.3. ADAPTABILITY		
3.2.3.1. *Adaptability of the building system to the metric system:* the new building system should be adaptable to the metric measuring system in order to be compatible with other products of the local home-building industry.	Developed for the North American market, steel-frame houses come in the imperial measurement system. Adjustment to metric is possible, but it would be feasible only for a large of order of houses.	0

Continue...

3.2.4. DURABILITY		
3.1.5.1.*Estimated life-span of the building:* houses built with the new system should have an expected lifespan of 100 years.	Resistant to humidity and insects, the steel structure is extremely durable. Its lifespan is easily comparable with masonry.	2
3.3. ECONOMIC ASPECTS		
3.3.1. CONSTRUCTION COST		
3.3.1.1. *Cost of material and components:* these costs should match the existing local prices of 325 - 650 Can$/m² (30 - 60 Can$/sq. ft.).	Even though the steel-frame house is about 5% more expensive than wood-frame, it still matches this price range of 35 - 60 Can$/sq. ft. The final cost, naturally, depends on the number of units built.	2
3.3.2. LABOUR COST		
3.3.2.1. *Labour cost:* Labour costs (both Canadian and local) should not exceed the amount of 225 - 330 Can$/m² (21 - 30 Can$/sq.ft.), or 30% of total cost.	Even with reduced construction time, the cost of Canadian labour required to implement the system, which is approximately 8 times more expensive than local labour, would dramatically increase labour costs.	0
3.3.3. TRANSPORTATION COST		
3.3.3.1. *Transportation cost:* Transportation cost should not exceed the price of: 70- 100 Can$/m² (6.5 - 9.2 Can$/sq. ft.), or 10% of the total cost.	Steel studs are stackable and do not take too much space in transportation. According to manufacturers, transportation costs can meet this criterion.	2
3.4. PSYCHOLOGICAL ASPECT		.
3.4.1. HOMEBUYERS ACCEPTANCE		
3.4.1.1. *Reservations towards performance of the house:* the newly introduced building system should be easily adaptable to design and finishes that are preferable for homebuyers in the COFY.	A house build using the steel-frame structure can be designed to easily meet the preferences of local homebuyers. Also, applied finishing does not have to reveal the structure of the house. However, the author thinks that this building system is too advanced for the housing market of COFY.	0
3.4.1.2. *Requirements for regular maintenance:* regular maintenance should be within self-help ability of the average homeowner.	The steel-frame itself does not need any maintenance. Still, some applied finishing (e.g. gypsum-boards) can require more frequent repairs than masonry.	1
3.4.2. BUILDERS' ACCEPTANCE		
3.4.2.1. *Availability of materials and components:* building system that involves materials and components available in local markets would have an advantage over the others.	As with wood-frame building systems, not all components are available locally, and this could create difficulties for later repairs and renovations.	0

Continue...

3.4.2.2. *Availability of skilled labour:* the potential for a building system to employ available and inexpensive local labour with a minimum of specialized training.	As steel-frame houses have no tradition in the market of the COFY, local labour would require a certain amount of training in order to be able to implement this system.	1

Marks: 2 - Fully satisfy the criterion;
1 - Partly satisfy the criterion, but adjustments are possible;
0 - Do not meet the criterion.

Total points: 18

As was mentioned earlier, the light-weight steel framed houses are still being introduced in, to the Canadian market. There are some attempts to export them to other countries, such as Germany, Russia and Portugal. However, besides their obvious advantages, especially in the area of structural strength, the author believes that, at this point, this building system would not be accepted in the COFY. The main reason for this is the necessity of framing directly on site, which requires specialized skilled labour, which is unavailable in the local building industry. Canadian labour would drastically raise the cost and thus the total price of the house. Also, the psychological barrier could be too strong. In the Canadian housing market, people have experience with the frame structural system, and they still show reservations towards steel as a material for housing, even though the difference is not visually evident once the house is completed. These reservations can be even greater in cultures where masonry is the main building system. Like in the case of the wood-framed houses, the housing market of the COFY would rather accept prefabricated houses that comes as a package.

Despite its obvious advantages, the author feels that it is too early for the housing market of the COFY to accept light-weight steel frame houses.

4.3. PLYWOOD / FOAM CORE SANDWICH PANELS

Plywood / foam core sandwich panels are made up of a core of insulating polyisocyanurate foam, pressure-injected between two sheets of oriented plywood particles. Expanding foam completely fills in the space between outside skins and, in its solid state, makes the panel perform as a monolithic structure. Tests performed showed very good resistance to compression, traction and shear.[34] They can be used for outside walls, interior walls, floors and roofing. This system is suitable for buildings up to three stories high, but also can be combined with other methods. It is also performing well in seismically unstable areas, because a well assembled structure acts as a three-dimensional spatial structure.

Dimensions of the panels are standardized at 4x8 ft and 4x9 ft, but the manufacturing process also permits other dimensions. This is certainly an advantage because the dimen-

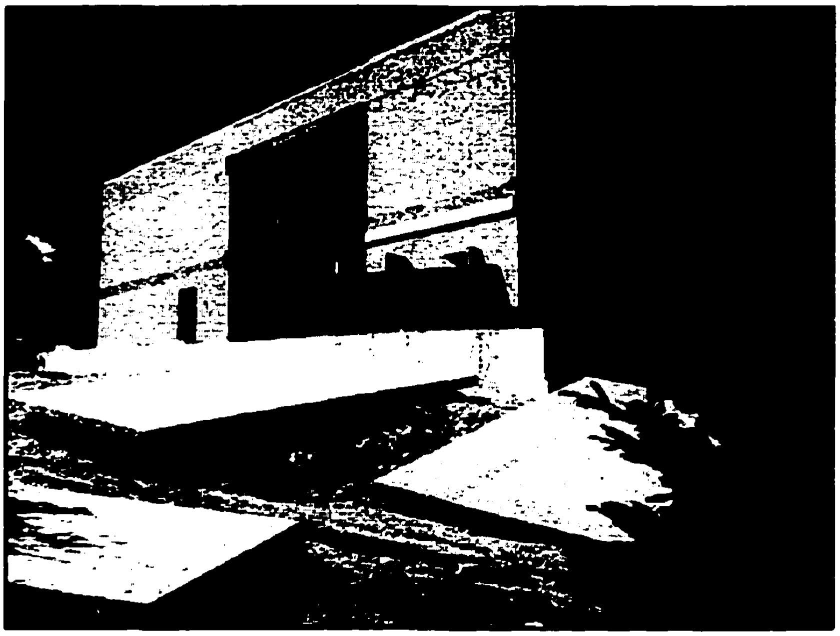

Figure 4.4: Plywood / foam core sandwich panels
Source: Canada's exportable houses, 1994

[34] Compressive strength: 0.22 MPa (32.4 psi), tensile strength: 0.21 MPa (30.2 psi), shear strength: 0.18 MPa (25.5 psi), density 40.0 kg/m^3 (2.5 lbs/cu. ft.). *(PAN-ISOX structural insulated panel, courtesy of Unlimited Housing Corporation 2001 Ltd., 1998).*

sions can easily be modified to fit the modular system used in the COFY. The thickness of the panels can vary. depends on their intended usage. For outside structural walls in residential buildings. the standard thickness is 117.7 mm (4 5/8 in). which provides thermal resistance of R-30. but this can be enlarged on demand. For interior walls. the thickness is usually 60.3 mm (2 3/8 in), and the polyisocyanurate foam acts as a good soundproofing barrier.

Light weight and simple assembly considerably reduce the construction time: it takes two men only 4 hours to assemble the walls of the house measuring 8 x 10 meters. All joints. such as the corner and roof joints are prefabricated. Once walls and floors are assembled. the openings for doors and windows can be cut out according to the design. regardless of their size and position. This again. is an advantage. because it opens up the possibility of using doors and windows produced by local manufacturers. which can additionally reduce the total price of the house. The fact that it is easy to assemble precludes the need for specialized skilled labour and special equipment and tools.

The construction costs (i.e. costs of materials and components) depend on the level and quality of finishing. According to producer (Unlimited Housing Corporation 2001 Ltd.). the price range for a median house would be between 330 to 450 CanS/m^2. The possibility of employing local labour would reduce the labour costs down to 150 to 200 CanS/m^2. Combined average costs of material and labour would thus be approximately 550 CanS/m^2. which is significantly lower than current price in the housing markets of the COFY (750 - 1100 CanS/m^2).

CRITERION	Comments and recommendations	Mark
3.2. TECHNICAL ASPECTS		
3.2.1. CODES AND REGULATIONS		
3.2.1.1. *Load-bearing capacity:* no specific requirements	Compressive strength of these panels is O.22 MPa (32.4 psi). Suitable for buildings of up to three floors high.	2
3.2.1.2. *Earthquake resistance*: no special approval necessary for the houses: - groundfloor+1 floor for VIII degree zones: - groundfloor+2 floors for VII degree zones.	Tensile strength: 0.21 Mpa (30.2 psi), shear strength: 0.18 Mpa (25.5 psi). Assembled well, the structure acts as three-dimensional spatial structure. Some additional reinforcements might be required in zones with higher seismical activities.	2
3.2.1.3.*Fire resistance:* no requirements for within one unit. Attached units must be separated by fire-walls with a fire-resistance of a minimum of 90 minutes.	These panels are considered combustible. Attached units need to be separated by fire-walls.	0
3.2.1.4. *Energy efficiency*: RSI requirements according to climatic zones: - outside walls: 0.66, 0.94, 1.08. - roof: 1.16, 1.37, 1.65.	Panels of standard thickness provides RSI of 5.3, which is more than the required. (Reducing the thickness of panels would decrease the structural strength).	2
3.2.1.5. *Acoustic*: no requirements for within one unit. Attached units need to be separated by walls which are able to achieve minimum soundproofing of 52 dB.	Polyisocyanurate foam acts as a good soundproof barrier. It will improve the acoustic comfort within the unit if panels are used as partition walls as well.	2
3.2.2. IMPLEMENTATION		
3.2.2.1. *Construction time*: the potential for house to be completed in less than 20 weeks.	It takes a two man team to assemble the walls of the house measuring 8 X 10 m in only 4 hours. Accordingly, a turn-key project should not take more than 8 weeks.	2
3.2.2.2. *Requirements for specialised skilled labour:* new building system should not require specialized skilled labour which is not available locally.	Simple assembly process of this system does not require specialized skilled labour.	2
3.2.2.3. *Requirements for specialized tools and equipment:* Building system should not require utilization of specialized equipment and tools, other than those already available within the local home-building industry.	Light-weight panels can be handled by men. Tools required for the job are standard carpenter's tools.	2

Continue...

3.2.3. ADAPTABILITY		
3.2.3.1. *Adaptability of building system to the metric system:* the new building system should be adaptable to the metric measuring system in order to be compatible with other products of the local home-building industry.	The panels can be made in any required dimensions without additional cost. Also, all openings can be cut in any sizes, so the system can be highly compatible with the products of local building industry.	2
3.2.4. DURABILITY		
3.1.5.1.*Estimated life-span of the building:* houses built with the new system should have an expected lifespan of 100 years.	According to manufacturer, the lifespan of a properly built and protected house can be compared to that of the brick house. Considering that this is a relatively new product, long term durability is not yet proved in practice.	1
3.3. ECONOMIC ASPECTS		
3.3.1. CONSTRUCTION COST		
3.3.1.1. *Cost of material and components:* these costs should match the existing local prices of 325 - 650 CanS/m^2 (30 - 60 CanS/sq. ft.).	It depends on finishing, but for a median house the price would be 330 - 450 Can/m^2 (30 - 45 CanS/sq.ft.).	2
3.3.2. LABOUR COST		
3.3.2.1. *Labour cost:* Labour costs (both Canadian and local) should not exceed the amount of 225 - 330 CanS/m^2 (21 - 30 CanS/sq.ft.), or 30% of total cost.	The involvement of inexpensive local labour and reduced construction time greatly reduce the price: the six men team would bring the cost of labour to around 100 Can/m^2 (10 CanS/sq.ft.).	2
3.3.3. TRANSPORTATION COST		
3.3.3.1. *Transportation cost:* Transportation cost should not exceed the price of: 70- 100 CanS/m^2 (6.5 - 9.2 CanS/sq. ft.), or 10% of the total cost.	Even though it is difficult to find out exact prices, light-weight panels are stackable and thus, easy to transport.	2
3.4. PSYCHOLOGICAL ASPECT		
3.4.1. HOMEBUYERS ACCEPTANCE		
3.4.1.1. *Reservations toward performance of the house:* the newly introduced building system should be easily adaptable to design and finishes that are preferable for homebuyers in the COFY.	It is reasonable to expect that there would be some reservations toward this building system, bearing in mind that it is considered "light", compared to masonry. However, the adequate design and finishing do not have to reveal the difference in structural systems. Still, it should be expected that this building system would not be widely accepted, at least in the beginning, especially in the owner-built part of the housing market.	1

Continue...

3.4.1.2. *Requirements for regular maintenance:* regular maintenance should be within the self-help capability of the average homeowner.	This building system allows a variety of finishing that corresponds with those used in traditional masonry. Properly chosen and installed, they might not required specialized maintenance more often than in the case of a traditional building system. Smooth surface of the panels allows immediate application of wall-papers or paint. Therefore, this type of maintenance is completely within the capability of the average homeowner. However, plywood panels might prove to be less resistant to humidity and insects.	1
3.4.2. BUILDERS' ACCEPTANCE		
3.4.2.1. *Availability of materials and components:* building system that involves materials and components available in local markets would have an advantage over the others.	Adaptability of this building system to required measurements makes it compatible with a variety of products from the local building industry. Also, easy production of the panels themselves makes it possible to establish the manufactures in the COFY, which would make this product easily available to the builders.	2
3.4.2.2. *Availability of skilled labour:* the potential for a building system to employ available and inexpensive local labour with a minimum of specialized training.	Local, inexpensive labour can easily be trained for the job.	2

Marks: 2 - Fully satisfy the criterion;
1 - Partly satisfy the criterion, but adjustments are possible;
0 - Do not meet the criterion.

Total points: 29

This building system allows different kinds of inside and outside finishing, which can enhance the appearance of the house and help overcome possible reservations toward new materials and components. Good performance of these prefabricated panels, and other above-mentioned advantages, make this building system acceptable in the market of the COFY.

4.4. CONCRETE / FOAM CORE SANDWICH PANELS

This building system is very similar to the previous one: expanding polyurethane foam is injected under pressure between outer light concrete layers. Each panel also has a built-in frame made of wood or steel, which protect the foam core, and through which panels are connected to each other with screws and bolts. The thickness of the concrete and foam layers, as well as the size of the panels, are adjustable, depending on specifications, which means that they can be easily adapted to the metric system and the local modular coordination system.

These panels show high performance in structural strength: the performed tests show that this system can withstand lateral forces of wind up to 120 MPH (210 km/h), and seismic tremors of zone III. They are firm, durable and resistant to humidity and insects. By regulating the thickness of the layers, different levels of insulation and rigidness can be achieved, in order to fulfill the various requirements of different climatic zones, as well as other building code requirements such as structural strength and acoustics. The assembly is simple and easy, and does not require any specialized tools, heavy mechanization or equipment. Also, local labour can easily be trained to do the work.

Smooth surfaces are ready for final finishing, and do not require substructure, as is in the case with gypsum drywall boards.[35] Also, different kind of outside finishing are applicable to these panels, so the appearance of the house could be adapted to meet local buyers preferences.

The openings in panels should be defined prior to manufacturing, because an opening should have its own frame which contributes to the rigidity of the panel and also serves as a substructure for attaching doors and windows. This would be the only major disadvantage of the system, because later alterations are not possible without affecting the per-

[35] This can work as an advantage, because, the kind of inside wall finishing such as gypsum-boards are not common in the countries of former Yugoslavia, at least not for the residential buildings.

formance of the panel. It means that this system is suitable for prefabricated houses. but not for a single, atypical design.

The price of these panels is similar to the previous one: between 350 and 450 CanS/ m^2 (this price include other materials and components, i.e. besides the panels comprises the total construction costs). Labour cost, also should not exceed 150 - 200 CanS/m^2. if local labour is employed for the construction. Therefore, even with transportation costs which are usually 8 - 10 % of the total amount, the total price of the house should not exceed 550 to 700 CanS/m^2.

CRITERION	Comments and recommendations	Mark
3.2. TECHNICAL ASPECTS		
3.2.1. CODES AND REGULATIONS		
3.2.1.1. *Load-bearing capacity:* no specific requirements	High performance in structural strength: 0.22 MPa (32.4 psi) in compressive strength. Allows building houses up to three stories.	2
3.2.1.2. *Earthquake resistance*: no special approval necessary for the houses: - groundfloor+1 floor for VIII degree zones: - groundfloor+2 floors for VII degree zones.	Rigid panels show good lateral forces resistance: shear strength: 0.18 MPa (25.5 psi). tensile strength: 0.21 MPa. The system works as a three-dimensional spatial structure.	2
3.2.1.3.*Fire resistance:* no requirements for within one unit. Attached units must be separated by fire-walls with a fire-resistance of a minimum of 90 minutes.	Outer concrete layers of sandwich panels protect foam core from combustion. However. longer exposure to fire can effect the structural strength of the panels. Attached units must be separated by masonry fire walls.	1
3.2.1.4. *Energy efficiency*: RSI requirements according to climatic zones: - outside walls: 0.66, 0.94, 1.08. - roof: 1.16, 1.37, 1.65.	Standard thickness of the panel makes the RSI value 5.2. Even though this is much more than required, reducing the thickness could affect the structural strength of the panel.	2
3.2.1.5. *Acoustic*: no requirements for within one unit. Attached units need to be separated by walls which are able to achieve minimum soundproofing of 52 dB.	Polyurethane foam core of the panel acts as an excellent noise absorbent. No additional noise reducers are necessary.	2

Continue...

3.2.2. IMPLEMENTATION		
3.2.2.1. *Construction time*: the potential for house to be completed in less than 20 weeks.	Approximate time to complete the house is 8 to 10 weeks.	2
3.2.2.2. *Requirements for specialised skilled labour:* new building system should not require specialized skilled labour which is not available locally.	Easy and fast assemblage does not require specialized trained labour.	2
3.2.2.3. *Requirements for specialized tools and equipment:* Building system should not require utilization of specialized equipment and tools, other than those already available in the local home-building industry.	Light-weight panels can be handled by man power. All tools required in the implementation are available in the local home-building market.	2
3.2.3. ADAPTABILITY		
3.2.3.1. *Adaptability of the building system to the metric system:* the new building system should be adaptable to the metric measuring system in order to be compatible with other products of the local home-building industry.	The panels can be made in any required dimension. Important: the size and place of openings needs to be defined prior to manufacturing. No alterations are possible after the panel is made.	1
3.2.4. DURABILITY		
3.1.5.1.*Estimated life-span of the building:* houses built with the new system should have an expected lifespan of 100 years.	According to manufacturer, it is comparable to masonry. Still, as this is a relatively new product, the performance of the foam core needs to be proved over the longer period of time	1
3.3. ECONOMIC ASPECTS		
3.3.1. CONSTRUCTION COST		
3.3.1.1. *Cost of material and components:* these costs should match the existing local prices of 325 - 650 Can\$/m^2 (30 - 60 Can\$/sq. ft.).	According to producers estimate, the price of material and components would be 35 - 45 Can\$/sq.ft.	2
3.3.2. LABOUR COST		
3.3.2.1. *Labour cost:* Labour costs (both Canadian and local) should not exceed the amount of 225 - 330 Can\$/m^2 (21 - 30 Can\$/sq.ft.), or 30% of total cost.	Employing local labour, along with the reduced construction time, would decrease the price of labour to around 100 Can\$/m^2.	2
3.3.3. TRANSPORTATION COST		
3.3.3.1. *Transportation cost:* Transportation cost should not exceed the price of: 70- 100 Can\$/m^2 (6.5 - 9.2 Can\$/sq. ft.), or 10% of the total cost.	Even though it is difficult to provide accurate prices, the manufacturer estimated that transportation costs would match these limits.	1

Continue...

3.4. PSYCHOLOGICAL ASPECT		
3.4.1. HOMEBUYERS ACCEPTANCE		
3.4.1.1. *Reservations towards performance of the house:* the newly introduced building system should be easily adaptable to design and finishes that are preferable for homebuyers in the COFY.	Rigidness of the panels and their concrete outer layers makes them similar to the masonry in minds of potential buyers, and with adequate design and finishings this system can be successful. Still, it most likely would not be immediately adopted by the part of market that obtain their houses by self-help practice.	1
3.4.1.2. *Requirements for regular maintenance:* regular maintenance should be within the self-help capability of the average homeowner.	Hard concrete outer layers of these sandwich panels protect the foam core. Resistant to humidity, insects and impacts, these panels do not require specialized maintenance. Hard and smooth panel surfaces allow a variety of finishing, such as paint and wall-papering, the implementation of which is usually within the capability of the average homeowner	2
3.4.2. BUILDERS' ACCEPTANCE		
3.4.2.1. *Availability of materials and components:* a building system that involves materials and components available in local markets would have an advantage over the others.	This building system involves materials that are available in the local building industries, so eventually, the factories for production of panels could be set up in the COFY. Also, dimensional coordination with other components from the local building industry makes this system highly applicable.	2
3.4.2.2. *Availability of skilled labour:* the potential for a building system to employ available and inexpensive local labour with a minimum of specialized training.	Inexpensive local labour can easily be trained for the job.	2

Marks: 2 - Fully satisfy the criterion;
1 - Partly satisfy the criterion, but adjustments are possible;
0 - Do not meet the criterion.

Total points: 29

Affordable prices, together with good technical performance make these panels very appealing for the housing market of the former Yugoslavia. Still, the aspect of cultural acceptance can play a decisive role. These panels have a more solid appearance than any lighter frame system. With adequate design and finishing, houses built with this system have a good chance of being accepted in the COFY market.

4.5. PERMANENT INSULATED FORMWORK/CONCRETE SYSTEM

Although innovative in design and assembly features, this building system remains conventional in its essence: expanded polystyrene elements assembled together act as built-in formwork for reinforced concrete walls.

Figure 4.5: Permanent insulated formwork / concrete system. *Source: courtesy of Polycrete, 1998.*

Insulated forms are composed of two symmetrical expanded polystyrene panels, measuring 2.5 x 12 x 96 in (63 x 305 x 2438 mm). They are fastened together by T-shaped polymer fixtures that are inserted into end grooves on adjoining panels, and which also serve as a solid base for screws. The precise and continuous space between parallel panels is ensured by tie-rods, with a maximum distance of 9 inches between them. Reinforcing steel bars are attached directly to these tie-rods. Once poured, the concrete adheres perfectly to the surface of the forms, creating a concrete and expanded polystyrene sandwich wall. The usual thickness of the concrete portion is 6, 8 or 10 in (152, 203 or 254 mm), but it can be adjusted according to requirements. Also, the steel reinforcement can be regulated to meet different standards for load-bearing and earthquake resistance.

Expanded polystyrene formwork act as built-in insulation (R-value from 20 to 30): properly installed concrete leaves walls free of air-pockets and thermal bridges. Insulation properties of polystyrene panels also allow pouring concrete at extremely low or high temperatures, without compromising the hardening conditions within the forms; this feature can extend the construction season so that it lasts almost year-round.

Other advantages of this system are basically the same as those of other concrete structures: they retain their shape and do not deteriorate, therefore maintenance costs are minimized over the years. The structure is highly durable and fire resistant and thanks to its high density, the walls provide an excellent sound barrier. This wall system allows different inside and outside finishing styles: various types of siding, stucco, brick or stone veneer, according to preference. The simplicity of polystyrene panels assembly and the familiarity of the local labour force with concrete work results in the possibility of using local, less expensive labour for the construction.

Even though this system offers construction material costs similar to those of other building systems, overall costs can be significantly lowered due to many factors. Construction time is reduced up to 50 % of conventional masonry building time. The possibility of engaging a local labour which do not require special training, and which is less expensive than Canadian labour, can also effect the total cost. Transportation costs are lower than for other prefabricated systems, because polystyrene panels are light and easy to transport: concrete can be produced by local building industries whose prices are also lower than in Canada. The ability of the system to easily adjust to different measurements and local building code requirements can add up to additional savings, through use of other products made by local building industries.

CRITERION	Comments and recommendations	Mark
3.2. TECHNICAL ASPECTS		
3.2.1. CODES AND REGULATIONS		
3.2.1.1. *Load-bearing capacity:* no specific requirements	This system offers structural strength of reinforced concrete. It is suitable for multi-storey multi-unit buildings as well.	2
3.2.1.2. *Earthquake resistance*: no special approval necessary for the houses: - groundfloor+1 floor for VIII degree zones: - groundfloor+2 floors for VII degree zones.	These requirements can be easily met. Additional resistance can be achieved by adding more structural steel, according to engineers' recommendations.	2
3.2.1.3.*Fire resistance:* no requirements for within one unit. Attached units must be separated by fire-walls with a fire-resistance of a minimum of 90 minutes.	Concrete walls are non-combustible. However, smoke which is the result of burning of polystyrene panels is toxic.	1
3.2.1.4. *Energy efficiency*: RSI requirements according to climatic zones: - outside walls: 0.66, 0.94, 1.08. - roof: 1.16, 1.37, 1.65.	Built-in insulation of polystyrene panels achieves the R-value of 27.45 (RSI: 4.8).	2
3.2.1.5. *Acoustic*: no requirements for within one unit. Attached units need to be separated by walls which are able to achieve minimum soundproofing of 52 dB.	Massive concrete walls act as an effective sound absorbent. This feature is improved with the addition of polystyrene layers.	2
3.2.2. IMPLEMENTATION		
3.2.2.1. *Construction time*: the potential for house to be completed in less than 20 weeks.	According to the manufacturer, this system reduces the construction time by up to 50% compared to conventional masonry. Therefore, the criterion is fully satisfied.	2
3.2.2.2. *Requirements for specialised skilled labour:* new building system should not require specialized skilled labour which is not available locally.	The assembly of panels is simple and fast, and local labour is experienced with working with concrete.	2
3.2.2.3. *Requirements for specialized tools and equipment:* a building system should not require utilization of specialized equipment and tools, other than those already available in the local home-building industry.	Pouring concrete requires use of concrete pumps, as well as vibrators. Also, during erections of forms, scaffolding needs to be used to stabilize walls.	0

Continue...

3.2.3. ADAPTABILITY		
3.2.3.1. *Adaptability of the building system to the metric system:* the new building system should be adaptable to the metric measuring system in order to be compatible with other products of the local home-building industry.	The system can be adjusted to fit the metric measuring system and the local modular grid.	1
3.2.4. DURABILITY		
3.1.5.1.*Estimated life-span of the building:* houses built with the new system should have an expected lifespan of 100 years.	Concrete walls of this system can easily achieve even longer lifespan of the building with no changes in performance of the structure itself.	2
3.3. ECONOMIC ASPECTS		
3.3.1. CONSTRUCTION COST		
3.3.1.1. *Cost of material and components:* these costs should match the existing local prices of 325 - 650 Can\$/m^2 (30 - 60 Can\$/sq. ft.).	According to the manufacturer, the construction material costs are similar to other building systems. However, the large amount of concrete needed for this type of building can be very expensive, considering the price of cement in the local market.	0
3.3.2. LABOUR COST		
3.3.2.1. *Labour cost:* Labour costs (both Canadian and local) should not exceed the amount of 225 - 330 Can\$/m^2 (21 - 30 Can\$/sq.ft.), or 30% of total cost.	Reduced construction time results in reduction of labour costs.	2
3.3.3. TRANSPORTATION COST		
3.3.3.1. *Transportation cost:* Transportation cost should not exceed the price of: 70- 100 Can\$/m^2 (6.5 - 9.2 Can\$/sq. ft.), or 10% of the total cost.	Considering that only light-weight and stackable polystyrene panels need to be shipped, the transportation cost are approximately 3.5 % of the total cost. The concrete can be supplied by local concrete factories.	2
3.4. PSYCHOLOGICAL ASPECT		
3.4.1. HOMEBUYERS ACCEPTANCE		
3.4.1.1. *Reservations towards performance of the house:* the newly introduced building system should be easily adaptable to design and finishes that are preferable for homebuyers in the COFY.	It can be assumed that there will not be many reservations toward structural performance of this building system, because it is based on reinforced concrete. Because this building system offers performance which is the most similar to the conventional building system, it can be assumed that it is going to be more readily accepted than any "light" structural system.	2

Continue...

3.4.1.2. *Requirements for regular maintenance:* regular maintenance should be within the self-help capability of the average homeowner.	This system allows various types of finishing. Outside ones can be durable and their maintenance can be compared to masonry. Inside, though, this system requires gypsum boards, which require more frequent repair than the plastered masonry wall. However, application of finishing requires sub-structure, which makes the walls very complex.	1
3.4.2. BUILDERS' ACCEPTANCE		
3.4.2.1. *Availability of materials and components:* building system that involves materials and components available in local markets would have an advantage over the others.	All materials and components of this building system are currently available in the home-building industry of the COFY.	2
3.4.2.2. *Availability of skilled labour:* the potential for a building system to employ available and inexpensive local labour with a minimum of specialized training.	Local labour is very experienced in working with concrete, therefore, this system could be immediately implemented in the market of the COFY.	2

Marks: 2 - Fully satisfy the criterion;
1 - Partly satisfy the criterion, but adjustments are possible;
0 - Do not meet the criterion.

Total points: 27

However, a closer look at this system will reveal some disadvantages. The oversized thickness of walls makes this system inappropriate for low rise houses: the reinforced concrete walls are too heavy and too massive for this type of building, even in the region where masonry is the main building system used. Once made, concrete walls do not allow for any adjustment, without enormous additional cost. Permanent polystyrene formwork works well on the outside surface of the walls, but inside, the whole substructure which will carry gypsum boards finishing, and allow electrical, plumbing and other installations to take their place needs to be built. The horizontal structures offered with this system are light: either steel or wood trusses, and in contrast to the heaviness of walls.

Even though this system is the closest to conventional masonry, and most likely would be more acceptable to the housing industry of the countries of former Yugoslavia, the problems that this system brings are too close to the disadvantages of using masonry. The improvements that this system introduce are not significant enough to justify its application.

4.6. PVC EXTRUSION PERMANENT FORM / CONCRETE SYSTEM

Similar to the previous one, this system is based on the principal of elements which, when assembled together work as a permanent form for concrete walls. Pre-cut PVC extrusions slide into each other to form a hollow panel whose cavities are then filled with concrete. The walls are anchored to the concrete foundations by reinforcing bars. Additional reinforcements within walls can be added if needed. Houses of one to two floors high can be easily built with this system.

All elements are based on a 10 cm module, whose advantage is that it corresponds perfectly with the same module used in the building industry of the COFY. Based on the structural strength of the reinforced concrete, this system can resist lateral forces of the wind velocity up to 250 km/h, and earthquakes up to 7 degree of Richter scale. Roof structures can be made of wooden roof trusses, or from PVC extrusion filled with concrete.

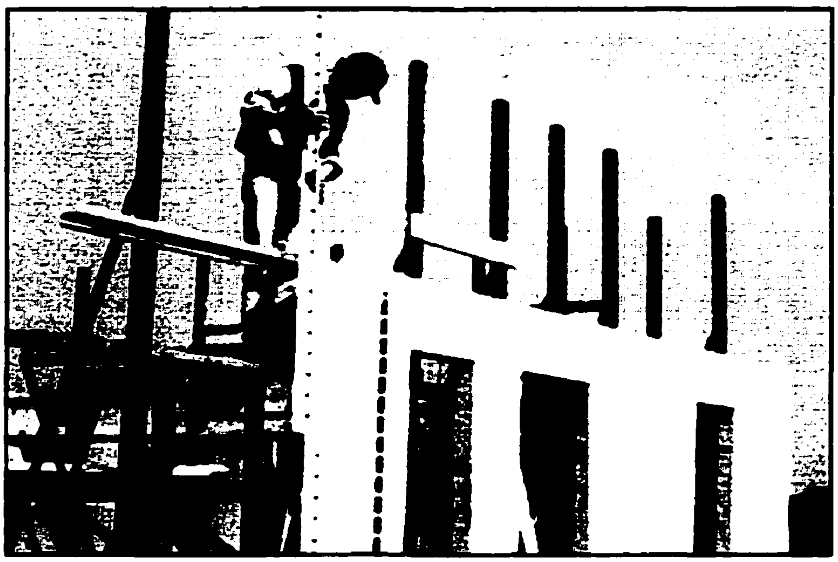

Figure 4.6: PVC extrusion permanent form / concrete system.
Source: courtesy of DIGIGRAPH, 1998.

Assembly of PVC extrusions is fast and simple, and a team of three men can assemble first storey walls in one day. The pouring of concrete, however, requires the involvement of the pumps, and better results would certainly be achieved if vibrators are used.

The small size of cavities require the use of concrete with more liquid consistency, which it makes more expensive. For an installation of electrical lines, a special, C-shape extrusion must be installed inside the walls before the concrete is poured. Similarly, the system requires that the water supply (plumbing) and the drainage system come up through the slab. The pipes can be included inside the walls prior to pouring the concrete. These features leave little freedom for post-occupancy adjustments or other renovations, which is certainly a disadvantage for the market in the COFY, where the house remain within one family for decades, and often need to be modified to accommodate the family's changing needs.

CRITERION	Comments and recommendations	Mark
3.2. TECHNICAL ASPECTS		
3.2.1. CODES AND REGULATIONS		
3.2.1.1. *Load-bearing capacity:* no specific requirements	Based on the structural strength of reinforced concrete, this system is appropriate for houses of one to two stories high.	2
3.2.1.2. *Earthquake resistance*: no special approval necessary for the houses: - groundfloor+1 floor for VIII degree zones; - groundfloor+2 floors for VII degree zones.	Tests proved that this system has earthquake resistance capabilities of 7 degrees on the Richter scale. Therefore, no specific features need to be added to meet the code requirements.	2
3.2.1.3. *Fire resistance:* no requirements for within one unit. Attached units must be separated by fire-walls with a fire-resistance of a minimum of 90 minutes.	Concrete walls are non-combustible. However, burning PVC extrusions can release the poisonous smoke.	1
3.2.1.4. *Energy efficiency*: RSI requirements according to climatic zones: - outside walls: 0.66, 0.94, 1.08. - roof: 1.16, 1.37, 1.65.	This system does not contain any kind of insulation. It needs to be added, according to requirements.	0
3.2.1.5. *Acoustic*: no requirements for within one unit. Attached units need to be separated by walls which are able to achieve minimum soundproofing of 52 dB.	10 cm thick concrete walls of this system do not entirely meet this criterion. An additional sound barrier should be installed between attached units.	1

Continue...

3.2.2. IMPLEMENTATION		
3.2.2.1. *Construction time*: the potential for house to be completed in less than 20 weeks.	Three men team can assemble first story walls in one day. Even though time is needed for the concrete to harden, and additional insulation and finishing need to be installed, the construction time can match the period of 20 weeks.	2
3.2.2.2. *Requirements for specialised skilled labour:* new building system should not require specialized skilled labour which is not available locally.	Considering the experience of local labour with concrete, this building system can be implemented even by owner/purchaser in the case of simple buildings.	2
3.2.2.3. *Requirements for specialized tools and equipment:* Building systems should not require utilization of specialized equipment and tools, other than those already available in the local home-building industry.	Concrete mixer, concrete pumps and even vibrators need to be used in order to properly install the concrete without air-pockets, which can effect the structural strength and create thermal bridges. Still, experience in work with concrete makes the most of these tools available in the local market.	1
3.2.3. ADAPTABILITY		
3.2.3.1. *Adaptability of building system to the metric system:* the new building system should be adaptable to the metric measuring system in order to be compatible with other products of the local home-building industry.	All elements of this system are based on a 10 cm module which perfectly correspond with local modular grid.	2
3.2.4. DURABILITY		
3.1.5.1.*Estimated life-span of the building:* houses built with the new system should have an expected lifespan of 100 years.	Durability of concrete walls correspond with conventional masonry. Still, PVC extrusions influenced by temperature changes might not be equally durable. This system still needs to prove its performance through practical use over long period of time.	1
3.3. ECONOMIC ASPECTS		
3.3.1. CONSTRUCTION COST		
3.3.1.1. *Cost of material and components:* these costs should match the existing local prices of 325 - 650 Can\$/m^2 (30 - 60 Can\$/sq. ft.).	According to the producers, the whole house kit together with doors and windows comes up to Can\$ 175/m^2. Still, the price of concrete, as well as of insulation and finishing is not included, so it can be assumed that it will reach Can\$ 300/m^2.	1
3.3.2. LABOUR COST		
3.3.2.1. *Labour cost:* Labour costs (both Canadian and local) should not exceed the amount of 225 - 330 Can\$/m^2 (21 - 30 Can\$/sq.ft.), or 30% of total cost.	Employing inexpensive local labour with reduced construction time can decrease the price to 95 - 130 Can\$/m^2.	2

Continue

3.3.3. TRANSPORTATION COST		
3.3.3.1. *Transportation cost:* Transportation cost should not exceed the price of: 70- 100 Can\$/m^2 (6.5 - 9.2 Can\$/sq. ft.), or 10% of the total cost.	PVC extrusions are stackable and the average house kit takes only 15 m^2 of shipping space. Therefore, the transportation cost is reduced to less than 3% of the total.	2
3.4. PSYCHOLOGICAL ASPECT		
3.4.1. HOMEBUYERS ACCEPTANCE		
3.4.1.1. *Reservations toward performance of the house:* the newly introduced building system should be easily adaptable to design and finishes that are preferable for homebuyers in the COFY.	The structure of this system is reinforced concrete, so it can be assumed that there will not be as many reservations toward structural performance. However, the solidity of concrete walls can make post-occupancy interventions in the house difficult, and very expensive Also, this system is not visually attractive. It is most suitable for less important buildings. As in other cases, finishing and design can influence this feature, but it brings additional cost and effort.	0
3.4.1.2. *Requirements for regular maintenance:* regular maintenance should be within self-help ability of the average homeowner.	Based on 10 cm thick concrete walls, the building system itself is extremely durable and does not require any maintenance. However, the need for regular maintenance will depend on the types of finishing used, and they can be chosen according to future buyers preferences.	2
3.4.2. BUILDERS' ACCEPTANCE		
3.4.2.1. *Availability of materials and components:* the building system that involves materials and components available in local markets would have an advantage over the others.	All materials and components except for the extrusions themselves are available in the home-building markets in the COFY.	1
3.4.2.2. *Availability of skilled labour:* the potential for a building system to employ available and inexpensive local labour with a minimum of specialized training.	Local construction workers are experienced in working with concrete and no additional training would be required.	2

Marks: 2 - Fully satisfy the criterion;
1 - Partly satisfy the criterion, but adjustments are possible;
0 - Do not meet the criterion.

Total points: 24

The price of this building system appears very attractive: the whole house kit which includes extrusions for walls, roof, windows and doors costs Can$ 175 per m^2. Extrusions are stackable and easy to transport: a kit for a house occupies approximately 15 m^2 of shipping space and weighs about 2,000 kg, which significantly reduces the shipping costs. However, several other elements must be added to the price. The price of concrete is not included into this amount. Even though the concrete work might be less expensive in the COFY than in Canada, the necessity of using concrete of a more liquid consistency makes it more expensive because more cement needs to be used. Second, this system does not include any kind of insulation, nor inside or outside finishing. The price of these materials and the cost of their installation needs to be added to the aforementioned price. Also, the installation of wall finishing itself can be complicated because it involves drilling solid concrete walls, and building additional substructures which would carry them. It is easy to conclude that these additional costs are likely to bring the price closer to that of other building systems. Thus, with all disadvantages that this system has, it does not make it efficient enough.

CHAPTER 5:
CONCLUSION AND RECOMMENDATIONS

After contacting Canadian manufacturers and exporters of housing building systems and prefabricated homes. the choice was narrowed to six building systems that were evaluated by the author. These systems differ in the materials used or in their structural principles.

These six systems can also be divided according to the nature of the systems themselves: frame structures are represented by wood and light steel frame structures: plywood or light concrete shell sandwich panels represent second group: and in the third group are systems based on the poured-in-concrete principal with different kinds of built-in formwork.

Every system was analyzed according to criteria developed for that purpose. Systems were approached from different aspects. such as technical (technological). economic. and psychological aspects (acceptance). The technical aspects include local building codes' requirements. implementation. compatibility with local building industry products. and durability of building systems. The economic aspect deals with the costs of components. labour and transportation. and the psychological aspect is concerned with the question of acceptance. both by potential buyers and by builders and developers.

The marking system that was used in the evaluation involved three levels of grades: 2 points were given for entries where building systems fully satisfy (or even exceed) the requirement. One point was given for entries where building systems could be adjusted to meet the criterion. and 0 points were given for entries where evaluated systems could not offer satisfying solutions.

After evaluation, the following results were obtained:

- Wood-frame prefabricated building system: 21 points;
- Light-weight steel frame building system: 18 points;
- PVC extrusion permanent form / concrete system: 24 points;
- Permanent insulated formwork / concrete system: 27 points;
- Concrete / foam core sandwich panels: 29 points;
- Plywood / foam core sandwich panels: 29 points.

However, it would not be right to hastily conclude that the concrete / foam core sandwich panels are the ultimate solution for problems in the housing industry of the countries of the former Yugoslavia, even though this system satisfies most of criteria. The author would like to take the opportunity to further expand and compare the performances of different systems.

All building systems show excellent results in implementation time, and even in the total price of the house, compared to the conventional masonry that is used in the housing industry in the COFY. These features were defined as major problems that burden local housing industries, apart from economic difficulties. Using any of the offered building systems presented, a house can be completed in less than 20 weeks, which is a significant improvement on the average 18 months construction time. In terms of prices, the research revealed that the prices of materials and components are equal to or less than local ones. Reduced construction time provides additional savings in labour costs, so even with transportation expenses, the total price of Canadian houses is competitive with local prices (land excluded). Still, there are many differences and obstacles that prevent immediate implementation of any of these building systems in the COFY housing market.

From results gathered, it can be immediately seen that both wood and steel-frame are far behind other systems. This surprising discrepancy between the performance of frame systems, which are well established in North America, and have definitely proved their quality here, and other systems, has its roots mostly in the essential differences between them. The advantages, such as reduced construction time and high efficiency, cannot be recognized in the housing market of COFY because of the lack of highly qualified labour used to build frame houses. Also, the main steel frame advantage over the wood, that is a non-combustible structure that reduces house-insurance costs, is applicable here in North America, but it is of very little importance over there. Local building codes do not even deal with this issue, because non-combustion is presumed to be a feature of masonry. Similar to this is acoustic comfort, where brick partition walls offer a satisfactory sound barrier within one dwelling unit.

The other group of criteria where frame structures failed compared to the others is maintainability and durability, as well as cultural acceptance. A closer look at these features reveals that, besides their technical characteristics, they are greatly related to the culture and traditions of the people in that part of Europe. Unlike North America, where a house is a product, which can be sold and replaced relatively easily at the time when it no longer meets the needs of a family, a house in the COFY is considered to be an investment for a lifetime, and it usually stays in the family for generations. There are many reasons for this: most of them are of a traditional and economic nature. For people in the COFY, a house must be built solidly, of hard material which does not need many repairs or maintenance, simply because these are expensive. Also, many people like (or they are forced economically) to build and to maintain a house by themselves. Introduction of new materials, such as gyprock boards for partitions, can be refused by potential buyers, simply because they lack the experience of working with these kinds of materials.

On the other hand, building systems that involve any type of concrete work are more likely to be accepted in the housing market of the countries of the former Yugoslavia. Again, it has much to do with the cultural mind-set of the people, more than with any real advantages that these systems offer. For example, the permanent insulated formwork / concrete system, in Quebec produced under the name Polycrete, performs very well in the evaluation. Besides its obvious structural and acoustics qualities, as well as its fire and earthquake resistance, the familiarity of local labour with its implementation would make it immediately applicable.[36] Because of these characteristics, this system would be able to overcome obstacles of cultural acceptance without much difficulty. Also, because it is suitable for multi-storey structures, it can have wider range of application. Besides low-rise single family houses, it can be used for mid-rise apartment buildings, and commercial buildings as well, and thus would provide more opportunities for its exporters. However, more critical analysis shows that this system does not always justify its usage for low rise buildings: its walls are too thick, and neither structural nor thermal regulations require this amount of expensive concrete. Besides this, once they are made, concrete walls are very difficult to modify, so possible post-occupancy changes are almost impossible. The PVC extrusion permanent form system presents the same problem, along with the need for additional insulation and inside finishing (gyprock boards), which can significantly enlarge the total cost.

Of all the systems, sandwich panels offer the most plausible solutions. Structurally strong enough, they contain enough insulation to be able to improve the energy efficiency of houses in the countries of the former Yugoslavia. Also, they are easily adaptable to the metric system, and therefore, compatible with other components of the local building industry. Suitable for one or two storey houses, they are easy to assemble by local labour. Smooth surfaces allow any kind of finishing both inside and outside. Adequate outside finishes, such as stucco, will contribute to the appearance of the house and make it more attractive to potential buyers. Affordable prices of the components themselves as well as easy transportation can make them more accessible for the housing market of the countries of former Yugoslavia.

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[36] In fact, Polycrete is currently negotiating the possibility of exporting to FR Yugoslavia and neighboring countries.

As was discussed earlier, the introduction of new products to the market is not an easy task, especially in the home building industry. However, in the market where owner-built homes account for almost 50 % of newly built units a year, and can be found at all income and social levels, it is somewhat understandable why there are more reservations toward new products. That is why building systems closer to masonry in their nature, such as concrete / foam core sandwich panels and permanent insulated formwork / concrete system, performed much better in this evaluation, even though their technological and economic advantages are not that notable compared to others.

Still, even with competitive pricing on the housing market, it is not realistic to expect that a potential exporter from Canada would immediately be successful. As was already pointed out, the inadequate building system is only a part of the problem that burdens local building industries in the COFY. Even though the housing shortage is evident and in some areas even acute, the weak economy and decreased purchasing power of the population are real problems that affect their housing market. As long as there are no adequate financing assistance programs from governments or banks, it is unlikely that the developing industry for the construction of moderately priced houses can evolve in any way. Until then, the export programs are possible only if they target the upper income group, which is only a small part of the market.

To be feasible, the newly introduced building system needs to be implemented in a large number of houses. Small building companies that are emerging today in the COFY are capable of carry out less than ten constructions a year. Thus, individually, they would not be adequate partners in Canadian exporting program. At this time, it would be much better for Canadian manufacturers to enter the housing market of the COFY through international community programs that are involved in rebuilding and revitalizing areas in Bosnia and Herzegovina and Croatia that were affected with war destructions. First of all, the housing shortage is the greatest in those areas, and amount of homes needed will economically justify the export, as well as provide a stabile market for at least the next five years.

Secondly, during that time Canadian-made houses will be able to prove their quality and efficiency and will become more attractive by overcoming the reservations of both future owners and builders in the area and in neighbouring countries. Also, the presence of alternative building systems would induce competition, and provoke the otherwise inert building industry to investigate the making of new products.

This thesis is a review that of the building systems most likely to be accepted in the housing markets of the COFY. The next step would involve undertaking a more detailed feasibility study for selected systems, in order to provide more precise information both for Canadian exporters, and for builders and developers in the housing markets of the COFY. That study should also include the design of one or several pilot units, with detailed analysis of implemented materials and components in order to determine the most successful combination for all sides involved: Canadian manufacturers and exporters, builders and developers of COFY, and most of all, potential future homebuyers.

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