Burj Khalifa as a Technical Object:

Re-visualizing the Technological Innovation of the World's Tallest Building through Simondon's Philosophy

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To my family

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Abstract

Burj Khalifa as an event involves a different meaning than just being the most recent tallest building in the world. It is the first time that human beings have been able to construct a building of its height: 828 meters. Furthermore, it is the first time that the height of a building has exceeded the world's latest tallest building by more than 60 percent. In the midst of this rare human accomplishment, interpretation and understanding of this achievement seem ambiguous or even incomprehensible. Despite the initial conviction about the influential role of technology in the emergence of Burj Khalifa, this conviction is not enough to explain its technical innovation. In other words, trying to confine the technological achievements and innovation of Burj Khalifa within the instrumental view of technology drains the event of its importance and raises many questions. In this light, the idea of the technical object in Simondon's philosophy offers a new approach for understanding the reality of technical innovation in Burj Khalifa. Thus, the guiding research question focuses on how the technical object can be a mode for perceiving the extraordinary achievement of Burj Khalifa. How can realizing Burj Khalifa as a technical object answer the question about what its technical innovation is? Indeed, it is a perspective to establish Burj Khalifa as a technical object in which the true moment of innovation is when the system (ensemble) leaps and passes a threshold and a new regime emerges that is able to find a kind of self-solidarity. Perhaps there were many extrinsic influences and potentials that participated in saturating the milieu for the emergence of the world's tallest building and produced Burj Khalifa. However, they did not go beyond producing repeated products—the tallest building or a repetition of the world's previous tallest building with a margin for a few changes. While the real evolution of Burj Khalifa is intrinsic (technical evolution), when it is concretized as a technical object in which the intrinsic potentials of its systems synergize into one ensemble, it reveals a new regime directed to achieving the target: the appearance of Burj Khalifa as the world's tallest building ever.

Résumé

En tant qu'événement architectural, Burj Khalifa n'est pas seulement le nouveau bâtiment le plus haut au monde. C'est la première fois que l'Homme est capable de construire aussi haut: 828 mètres. C'est également la première fois que la hauteur d'un bâtiment excède de plus de 60% celle du précédent gratte-ciel le plus haut du monde. La manière dont cet accomplissement est interprété et compris peut sembler ambiguë, voire incompréhensible. Malgré l'idée initiale qui attribue l'émergence de Burj Khalifa à la technologie, cette conviction n'est pas suffisante pour expliquer son innovation technologique. En d'autres termes, considérer les prouesses et innovations technologiques de Burj Khalifa comme une technologie instrumentale serait une minimisation de leur importance et soulèverait de nombreuses questions. Sous cet angle, l'idée d'un objet technique, exposée dans la philosophie de Simondon, offre une nouvelle approche de l'innovation technique de Burj Khalifa. Ainsi, la question directrice est axée sur la manière dont l'objet technique peut être un mode de perception de l'extraordinaire réalisation qu'est Burj Khalifa. Comment le fait de considérer Burj Khalifa comme objet technique aide-t-il à comprendre ce qu'est l'innovation technique ? De fait, c'est une perspective qui tend à positionner Burj Khalifa comme objet technique pour lequel la vraie innovation réside dans le moment où le système (l'ensemble) passe un cap et où un nouveau régime, cohérent et organisé, émerge. Peut-être y-a-t-il eu de nombreuses influences extérieures ayant participé à préparer un terrain propice à l'émergence des plus hauts grattes-ciel au monde, et ayant contribué à produire Burj Khalifa. Elles ne sont cependant pas allées plus loin qu'une simple répétition de systèmes – le bâtiment le plus haut n'était qu'une reproduction de son prédécesseur, avec une marge de changement. L'innovation apportée par Burj Khalifa est intrinsèque (évolution technique) dans la mesure où il s'agit dans objet technique au sein duquel les potentiels intrinsèques de ses systèmes se conjuguent en un ensemble ; c'est un nouveau régime créé pour achever un but précis: positionner Burj Khalifa comme le bâtiment le plus haut jamais construit.

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Introduction

Discussing tall architecture is not a matter of the present moment but belongs to the beginnings of its appearance in the late nineteenth century and what brought about the controversies over its existence. Its prevalence and spread as a manifestation of modernity, coinciding with modern technology's elevation techniques, construction methods and structural systems, have, however, carried that debate to a broader domain. Gradually, tall architecture has become an icon of technological evolution, reinforced by its embracing, predominantly, the latest and highest technological innovations. Nevertheless, no one can assert whether or not tall architecture or the world's tallest buildings with what matters as influence and importance are technical objects, nor can one confirm that their concretization as a system reveals a genuine technical object. Perhaps part of this ambiguity is the essence and meaning of the technical object itself, especially in architecture.

From this perspective, the research adopts the concept of the technical object in Simondon's philosophy and thus focuses on the possibility of emerging tall architecture as a technical object. The research outlines the real meaning of technological innovation in the world's tallest buildings through the idea of the technical object in which the true moment of invention is when the regime leaps into operative self-solidarity by passing a threshold (critical point). That is the moment that reveals the concretization of the technical object, which is simply a process through which that technical object progresses analogically according to living beings' thoughts and becomes capable of being durable, sustainable and able to interact with its milieu effectively. In fact, the emergence of the new regime at that moment makes us think thoroughly about the system that is concretized as a technical object. Therefore, arguing for the idea of the technical object in tall architecture seems clearer when the matter is discussed through a specific model, for which Burj Khalifa has been chosen in the present research.

Burj Khalifa is an ambitious project carrying different dimensions of meaning, which stem mainly from its unique status as the tallest man-made building ever. It is the first time that one building has succeeded in exceeding through its height all previous records of height whatever their classification: for instance, the tallest building, the highest occupied floor, the highest roof area, the tallest building structure and the highest antenna tip. Not only this, but the challenge took on another dimension when it became a challenge to itself, which explains its success in exceeding more than 60 percent in height the world's former tallest building—Taipei 101. In the midst of these achievements, we have to keep in mind that Burj Khalifa is a building subject to all the requirements of appropriateness for tall buildings.

The research aims fundamentally to understand the extraordinary technological achievement of Burj Khalifa through the idea of the technical object. Thus, how can Burj Khalifa be revealed as a technical object? In other words, this is an approach to prove that Burj Khalifa with its exceptional achievement must be a technical object. This research from the general point of view is an examination and re-evaluation of the reality of technical innovation in Burj Khalifa by exploring its appearance as one coherent ensemble of different systems. Defining Burj Khalifa as a technical object at the ensemble level contributes to establishing our view about the reality of its organization as a network of different systems in which each system has two layers of roles (functions): as an individual system it has a specific role, and as an element in the ensemble it synergizes the main direction of the entire ensemble.

Based on the above considerations, the research is divided into two fundamental parts. Chapter one focuses on illustrating the main dimensions of the technical object in Simondon's philosophy, which in total determines the knowledge frame of the second part of the research. Chapter two is devoted completely to arguing for Burj Khalifa as a technical object.

Revealing Burj Khalifa as a technical object provides an explanation about the fact of its achievement as the world's tallest building. The deep examination of the emergence of Burj Khalifa shows that there were many potentials that participated in saturating the milieu to cause the emergence of the world's tallest building. However, they did not go beyond producing repeated products—the tallest building or a repetition of the world's existing tallest buildings with a margin for a few changes. The real transformation in Burj Khalifa as an exceptional achievement is a technical evolution due to the intrinsic potentials of its system. For example, the economic power of Dubai can be considered as the main influential factor in appearing Burj Khalifa, but the real grasp of Burj Khalifa and the nature of its achievement shows that the effect of this factor did not exceed the influence of producing an ordinary tall building or a repetition of the previous achievements in the world of tallest buildings generally. This prompts one to think seriously about the nature of the potentials that contributed to the emergence of Burj Khalifa. In point of fact, understanding the real roles of the intrinsic and extrinsic potentials assumes two dimensions. The first includes the producing potentials, which are mostly extrinsic and cause the milieu to be oversaturated; as well, they are responsible for finding Burj Khalifa as a model for tallest buildings. The second dimension is the technical evolution when Burj Khalifa is concretized as a technical object in which the intrinsic potentials of the systems of it synergize and the ensemble leaps forward, revealing a new regime that aims at achieving the target—the concretization as the world's tallest building ever. Identifying Burj Khalifa as a technical object means that we recognize it as a pure technical invention, which in turn does not refer to the traditional hylemorphic notion according to which a person has an idea and then builds something that corresponds to that idea; rather, it is the birth of a new regime occasioned by the operation of recurrent causality involving the actual operation of the technical object itself.

Undoubtedly, arguing for Burj Khalifa as a technical object can be considered a distinct attempt to understand and interpret tall architecture and its technological innovations, which will reflect thoroughly on our ways of realizing and evaluating the performance of tall architecture generally in its environment and, thus, participate significantly in changing our ideas about designing them.

Literature Review

Discussing Simondon's notion of a technical object in architecture, and particularly in tall architecture, is a new topic, which explains the paucity of literature in this field. Therefore, most discussions of the idea of the technical object are within the boundaries of the philosophy of technology, from which it emerged. On the contrary, tall architecture and in particular Burj Khalifa, the second part of the research, occupy a large area of discussion, especially in the technological field. Reviewing the previous literature has been done independently through three topics, which reflect to a large extent the directions of the research: the technical object in Simondon's philosophy; tall architecture and Burj Khalifa as a model; and Dubai as a place that embraced the appearance of Burj Khalifa.

There are two kinds of literature that discuss the technical object. The first, which conveys the original ideas of Gilbert Simondon about the technical object, is represented here by Simondon's PhD dissertation, *On the Mode of Existence of Technical Objects*. This reference is the key text that determines the features of Simondon's views on a philosophy of technology. Simondon, in its introduction, highlights the disharmony between culture and technology in our knowledge, which explains the position against technics, which in turn is seen as a defence of the human being. Simondon imputes this dissonance to refused human reality in technical objects and insists that it be taken into account that there is a human reality in technical reality. Simondon aims to create an awareness of the significance of technical objects, whose modes of existence are determined through philosophical thought.[1] He sees the role of the technical object in relation to humanity as being similar to the role that the emancipation from slavery played in the affirmation of the value of the human being.[2] From the point of view of my research, the importance of Simondon's dissertation occurs on three levels: the general knowledge about Simondon's philosophy; the specific knowledge about the technical object; and, finally, Simondon's methodology in analyzing the models. Simondon lays out the main ideas of a technical

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[1] Gilbert Simondon, *On the Mode of Existence of Technical Objects,* trans. Ninian Mellamphy (London, Ontario: University of Western Ontario, 1980), 11.

[2] Ibid.

object and its elements, such as milieu, invention, indeterminacy, concretization etc., which represent entirely the theoretical frame of my research. In addition, he determines that the technical object can give rise to very different attitudes, depending on whether it is taken at the level of the element, at the level of the individual, or at the level of the ensemble, in which technicity tends to reside at the present time.[3] Thus, the influence of defining the level and determining the characters of the technical object seem crucial in its realization. Although defining the level of each object depends on its complexity and contents, Simondon actually includes other conditions in this definition, such as the associated milieu and technicality. For instance, he sees that the associated milieu is the condition for the existence of the invented technical object at the element and individual level, while the creation of a single associated milieu at the ensemble level is undesirable.[4] In the classification of the technical object's levels, Simondon addresses the location of the human being in relation to the technical object through enhancing the real role of the human being. In this light, the human being is the permanent organizer of a society of technical objects that needs him in the way musicians need a conductor in an orchestra.[5] The careful examination of Simondon's models, such as the Guimbal turbine, shows obviously a method of arguing the idea of the technical object in which Simondon tends firstly to introduce the technical description of the systems, including a preliminary perception of the purpose and function of the system. Then, a description of the concretization of technical object follows; and, finally, Simondon gives some hints about the process by summarizing the ideas generally. As part of completing the visualization of the ideas of the technical object, Simondon argues for the distinction between abstract and concrete technical objects, the conditions of technical evolution, the rhythms of technical progress and the absolute origins of a technical lineage. Simondon sees technical objects as mediators between nature and human beings.[6] To introduce a technical object to the culture he insists on the necessity of instituting a full comprehension of it initially.[7] Furthermore, Simondon

[3] Ibid.,16.
[4] Ibid., 54-56.
[5] Ibid., 13.
[6] Ibid., 50.
[7] Ibid., 14.

presents a new image of the nature of technical evolution in which the evolution of the technical object is a result of intrinsic causality rather than of extrinsic causality.[8] Therefore, this is the negative of dealing with technical objects from the industrialization point of view. On the other hand, the technical object provides a new measure of products that will allow for more possibilities in the future. Thus, standardization, according to Simondon, leads to creating an object with decorative elements that increase the burden on the object.[9] Simondon differentiates between evolution and improving. He stresses that achieving the technical object should be through evolution. Improving elements in the object, such as the parts of a car, does not enhance the technical object. Rather, doing so may decrease the technical object. Finally, the gradual building up of the ideas of the technical object in Simondon's models offers a road map to becoming aware of the meaning of the technical object.

In same context, Simondon's essay "Technical Mentality", which serves as an introduction to *Gilbert Simondon: Being and Technology*, can be considered a complement to the visualization of the technical object. Simondon in this essay "aims to show that there exists a technical mentality, and that this mentality is developing, and is therefore incomplete and at risk of being prematurely considered as monstrous and unbalanced."[10] In fact, understanding the technical mentality is the keystone to understanding Simondon's philosophy of the technical object. He intends to prove the existence of a technical mentality as being coherent, positive, and productive in the domain of the cognitive schemas.[11] Besides, he shows that the technical mentality is "incomplete and in conflict with itself in the domain of the affective categories because it has not yet properly emerged."[12] Technical mentality as cognitive schemas, for Simondon, is "a mode of knowledge that essentially uses the analogical transfer and the paradigm."[13] Furthermore, "it founds itself on the discovery of common modes of functioning—or of regime of

[8] Ibid., 21.

[9] Ibid., 22.

[10] Gilbert Simondon, "Technical Mentality," in *Gilbert Simondon: Being and Technology,* ed. Arne De Boever, Alex Murray and Jon Roffe (Edinburgh: Edinburgh University Press Ltd., 2012), 1.

[11] Ibid.

[12] Ibid.,2.

[13] Ibid.

operation—in otherwise different orders of reality that are chosen just as well from the living or the inert as from the human or the non-human."[14] The theoretical structure of the technical mentality makes us see the object as not only structure but also regime. Accordingly, for Simondon, "the normalization of thresholds of functioning expresses itself in the difference between relatively separate subsets of the whole."[15] Also, "the degree of solidarity is precisely the measure of the relation between the permanent parts and the parts subject to replacement."[16]

The second source is the literature that discusses Simondon's philosophy generally. *Gilbert Simondon: Being and Technology*, *Gilbert Simondon and the Philosophy of the Transindividual* and *The Philosophy of Simondon: Between Technology and Individuation* can be considered the main sources in this field.

Gilbert Simondon: Being and Technology, which is a collection of essays, shows the importance and the influences of Simondon's philosophy and is arranged so as to be a stepping stone to understanding Simondon's philosophy and the field of its application. The book starts with "Technical Mentality," which I noted earlier, and the rest of the book is divided into three parts: Explications, Implications and Resonances. Although there is a wide range of ideas and opinions in the book, "'Technical Mentality' Revisited: Brian Massumi on Gilbert Simondon" plays a pivotal role in enhancing the idea of the technical object. It is an interview with Brian Massumi, who presents a novel reading of the technical mentality according to the current trends and explores the potentials of Simondon's philosophy at the present time. Theoretically, this chapter of the book broadens the comprehension of the technical object and Simondon's philosophy. In this light, Massumi emphasizes identifying the schema of concretization with the cognitive schema. Accordingly, understanding the cognitive schema as an abstract model means that it is entirely internal to the human thinking subject.[17] Thus, the cognitive schema comes before

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[14] Ibid.,1.

[15] Ibid., 13.

[16] Ibid.

[17] Arne De Boever, Alex Murray and Jon Roffe, "Technical Mentality' Revisited: Brian Massumi on Gilbert Simondon," in *Gilbert Simondon: Being and Technology,* ed. Arne De Boever, Alex Murray and Jon Roffe (Edinburgh: Edinburgh University Press Ltd., 2012), 24.

the object and guides its construction.[18] As an explanation of these ideas, Massumi presents a re-reading of the Guimbal turbine as a technical object. In addition, the book also has an extensive glossary of the terms in Simondon's philosophy that makes it a complete handbook and reference guide to Simondon's thought.

The second book is *Gilbert Simondon and the Philosophy of the Transindividual* by Muriel Combes. It is based mainly on discussing Simondon's hypothesis, which posits a "pre-individual being" as the condition for the emergence of the "psycho-social" field. Accordingly, Combes sheds light on Simondon's thought and clarifies the operational relationships between the concepts structuring its innovative perspective and outcomes. Combes lays the groundwork for the unique paths of the thought that provides a perception of the essential relationship of the individual and the collective relative to their reciprocal and constitutive co-individuations. From the view of the technical object, Combes provides a reading of the technical issue and its relationship with culture. She starts from the same point where Simondon begins his dissertation: that there is a conflict between culture and technology. She looks to Simondon as a thinker of technics who "appears as a thinker of the resolution of a crisis of humanity in its relation to the world of technics."[19] Besides, she determines the reasons for such crises in the opposition between culture as a world of meaning and as a result of considering technics exclusively from the angle of utility.[20] Through provoking an awareness of the existence of technical objects, Simondon focuses not only on the usage of technics or the utilitarian intention that we may project onto them, but also on their genesis.[21] In same context, Combes notes the nature of the functioning schemas of technical objects not as fixed schemas but in temporal evolution.[22] On the other hand, the concepts of crystallization and the saturated milieu are seen as a kind of attention whereby Simondon provides an illustration of the process and its stages. Generally, Combes' reading of the theme of the technical object and its milieu

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[18] Ibid.

[19] Muriel Combes, *Gilbert Simondon and the Philosophy of the Transindividual,* trans. Thomas LaMarre (London: The MIT Press, 2013), 57.

[20] Ibid., 58.

[21] Ibid.

[22] Ibid.

looks like a rephrasing of what Simondon originally argues in *On the Mode of Existence of Technical Objects.*

The Philosophy of Simondon by Pascal Chabot is the third reference in the field. Although the book does not depart greatly from the main context of the two preceding sources, it attempts to establish the importance of Simondon's philosophy. Chabot focuses on the new philosophy that Simondon introduced and tries to explain what has made Simondon's philosophy suddenly the focus of attention. As well, he tries to link Simondon's late ideas and those that emerged at the beginning of his academic work. The book deals as well with some authors who discussed his philosophy and locates their ideas within the general context of Simondon's philosophy. As far as the technical object is concerned, the book succeeds in outlining the theme of the technical object in a different way through selecting and analyzing some case studies, which, subjectively, demystify the difficulty of applying the concept of the technical object outside Simondon's realm. Moreover, the treatment of the technical object in the book provides a kind of methodology for developing the theme of the technical object and how other ideas, such as concretization, regime, milieu, invention, inventor etc., can be combined with it.

The second part of this literature review is devoted to Burj Khalifa and the emergence of tallest buildings in general. It is appropriate to state here that the short period of existence of Burj Khalifa makes the literature dealing with it mostly technical reports. However, I defined three main resources that provide a wide view of tallest buildings.

Although it contains some information about Burj Khalifa, *The Tall Buildings, Reference Book* is on the whole a collection of essays that discuss designing tall buildings generally. The book begins with a historical introduction that covers the development of tall buildings; then it addresses topics that are considered essential in designing tall buildings, such as the human, social, urban, aesthetic and economic aspects. There is a tendency to deal with designing tall buildings from the technical viewpoint and architectural practices beginning from the procurement stage through the design and construction process to new technologies and the buildings' contribution to the urban habitat. Also, this includes some trends that participated significantly in improving transformation in designing tall buildings after 2000, which were involved directly in the case of the Burj Khalifa, such as increasing the number of tall buildings and their height remarkably, changing the centre of gravity of the proliferation of tall buildings in new centers, such as Dubai, the location of this research's case study, transforming the function of tall buildings and, finally, the dramatic change in the materials of and structural approaches to tall buildings.[23] Though technological innovations in tall buildings take up much of the space, there are concealed underneath general descriptions of the main topics, such as structural design, envelope treatment and others. From my research angle, the significance of the book lies in its containing Burj Khalifa as a case study for examining certain issues about tall buildings, such as the transformation in the definition of tall buildings, their social effect, structural behavior and design for wind, as well the general view of their design. Burj Khalifa as a case study takes on different dimensions since it engenders a new scale of technical and design requirements by being classified in a new generation of tall buildings—the Megatall—which has resulted in the re-crystallization of tall building codes.

The second source about tall architecture includes two collections of conference presentations: *Tall Buildings and Urban Habitat: Cities in the Third Millennium* in Melbourne in 2001 and *Tall Buildings from Engineering to Sustainability* in Hong Kong in 2005. Practically, the importance of these conference proceedings is to determine the atmosphere that preceded the appearance of Burj Khalifa through discussing factors that played a pivotal role in the design of future tall buildings. The conference topics, in general, do not depart from the main themes of designing tall buildings. But there is a focus on discussing the effect of technological innovation on tall buildings as a fertile field for developing tall buildings. The papers' importance lies in their chronology, which completes the picture of the evolution of tall buildings reaching up to Burj Khalifa, and the change in the balance of power that reinforced Dubai's entering the tall buildings realm as a new

[23] Antony Wood, "Tall Trends and Drivers: An Over View," in *The Tall Buildings, Reference Book,* ed. Dave Parker and Antony Wood (Oxford: Routledge, 2013), 1.

player with two projects, the Emirates Towers and Burj Al-Arab, the avant-garde of Burj Khalifa.

The last segment of my sources deals with the Dubai environment through exploring the circumstances that prepared for the emergence of Burj Khalifa. This part concerns the hidden portion of Burj Khalifa's story which crystalized the features of the environment in all aspects. It includes the following three sources:

Dubai: Behind an Urban Spectacle by Yasser Elsheshtawy discusses in many parts the concept of the transformation of Dubai from the traditional world to capitalism, and how Dubai occupies a gateway position linking east and west. Likewise, it explains the factors that led to this transformation, which crystalized the atmosphere through helping to change the structure of the city and emerged as a dominant trend towards vertical urbanism. However, this spectrum comprises a hidden part of that transformation that shows the other side (the dark face) of the city and completes the picture of Dubai.

On the other hand, we find Roland Marchal in "Dubai: Global City and Transnational Hub" focusing on the many attributes that contributed to Dubai's transformation into a global city within record time compared to other cities. Marchal clearly emphasizes the economic factor, but he also defines the special character of the structure of Dubai, which reflects in turn on its capacity. The essay lays out the dimensions that collaborated in individualizing the city: the relatively weak political status, the role of the state, the long duration of *cités-entrepôts* (warehouse cities), and the aggregation of business classes from different backgrounds.[24]

Finally, *Dubai Dreams: Inside the Kingdom of Bling* by Raymond Barrett is a journey into the past, present and future of Dubai that narrates and visualizes Dubai's explosion onto the global scene. Barrett reveals a mixture of contradictions that establish Dubai's identity in which expecting the exotic looks normal and achievable. Dubai, according to

[24] Roland Marchal, "Dubai: Global City and Transnational Hub," in *Transnational Connections and the Arab Gulf*, ed. Madawi Al-Rasheed (London: Routledge, 2005), 95.

Barrett, is "a place where the confines of the imagination no longer apply."[25] He emphasizes that Dubai has "forged ahead and exhausted billions upon billions of dollars to remake itself in an image of its own creation."[26] The story is not confined to this perspective but also extends farther to evaluate the position of Dubai in its surroundings, whether at the UAE level or in the Middle East, and the effect that has had on its goal in creating its own icon. The details of Dubai's life in all aspects, economic, social, political and others, are addressed by defining the features of Dubai's boom in mega-building projects.

[25] Raymond Barrett, *Dubai Dreams: Inside the Kingdom of Bling* (London: Nicholas Brealey Publishing, 2010), 1.

[26] Ibid., 3

Methodology and Structure

The main topic of the research, which concentrates on the theme of the technical object through Simondon's philosophy, made realizing the ideas of the technical object and the possibility of implementing them in tall architecture the keystone of the research. Although the idea of the technical object was revealed in the middle of the last century, architecturally, there is no clear direction about how to attain it in sophisticated systems such as buildings. Also, all the previous attempts that have dealt the concept of the technical object are rather far from architecture, which made constructing a clear method to implement the idea of the technical object in tall architecture a priority in the research. In this light, my first concern focused on exploring the principles of the technical object from the angle of architecture. In point of fact, the success of this stage lay in comprehending Simondon's examples from the architectural point of view and extracting the ideas that establish the first building blocks in the foundation of the knowledge frame for the technical object. Simultaneously, some recent practical attempts in other fields, such as automobiles and prosthetics, helped to provide a fresh view to perceive the idea of the technical object. Besides, I found that using a model to illustrate the idea of the technical object, which, as an approach, was used widely by Simondon in his treatise *Mode of Existence of Technical Objects*, would be helpful in delivering the idea smoothly and providing a clear visualization of the relation between the idea and the model. For this purpose, the Guimbal turbine was selected as the model. Illustrating the Guimbal turbine as model includes three levels of argument, the first of which contains a technical description of the model; then a demonstration of its concretization as a technical object; and, finally, an analysis of the concept of the technical object. This orientation made me consider at an early stage in the research the importance of defining a specific model in tall architecture, which culminated in my selecting Burj Khalifa as the model of the thesis. As a result, the research, conceptually, includes two main parts: establishing a knowledge frame for the technical object and then employing this knowledge in realizing Burj Khalifa as a technical object.

The next stage of the research, which covered the discussion of Burj Khalifa as a technical object, was not a new stage in the precise sense for the simple reason that it carried on my former experience in living and working, which extended for more than ten years, as a specialist architect in designing tall architecture in the city that embraced Burj Khalifa, namely, Dubai. This meant that the research at this stage was close to rereading and re-examining the events in new way. Further, the first stage, which was designated to argue for the technical object, already carried seeds of the next stage. Indeed, my closeness to the events that preceded and coincided with the appearing of Burj Khalifa contributed in an important way to supporting this part of the thesis.

The research in the second stage included two levels: one focused on Dubai and the other on Burj Khalifa. About Dubai, the knowledge frame of the technical object, especially the ideas of the milieu and crystallization, helped significantly to focus on the potentials of Dubai as place to embrace Burj Khalifa. The research at this stage adopted a historical orientation through analyzing the events that coincided with the appearance of Burj Khalifa. Therefore, the resources of this stage included newspapers, reports and interviews with people who had witnessed that period. On the other hand, the second part of this stage, which dealt with Burj Khalifa, involved the collection and analysis of its technical details. The nature of the project meant that the resources were not confined to a specific type; thus, for instance, a YouTube clip about a technical issue in Burj Khalifa could provide an answer to a sophisticated question. In fact, there was a flood of technical information that required finding a proper mechanism to organize and analyze. Arguing for Burj Khalifa as a technical object forced me to confront a crucial issue, which was how to discuss its level. Defining the level of Burj Khalifa as an ensemble was not enough to show how I would deal with the multiple systems that compose it. I admit here that this issue was my concern from the first moment of the research and took up a large part of my thinking. Of course, there was a direct method, which would be to enumerate and examine the systems of Burj Khalifa one by one and then move on to the whole ensemble. At first glance, this seemed inapplicable because of the number of Burj Khalifa's systems. This matter required analyzing many models that were presented as technical objects whether by Simondon's or others' definition and finding the key that could help me in discussing the ensemble of Burj

Khalifa. Eventually, I realized that the solution lay in comprehending the end of the concretization of the technical object, where the concept of the ensemble reveals two levels of the roles: the main direction of the ensemble and the synergy of the whole system towards achieving this direction. Hence, it seemed evident that the key was the value of Burj Khalifa as the world's tallest building, which defines the main direction of the ensemble. Thus, through focusing on the structural system as a technical object and the principle of the synergy of the other systems, which are also technical objects, the method became clear.

From the above, the thesis consists structurally of two chapters. The first highlights the main ideas of the technical object through the philosophy of Simondon. In this chapter, I argue for the technical object as a general principle; then, through the example of the Guimbal turbine, which I selected as the illustrative model, I focus on the main ideas of the technical object, such as the role of the milieu, the levels of the technical object and the idea of concretization, as well as the role of the inventor.

The second chapter comprises two parts. The first is devoted completely to defining the potentials of Dubai as a privileged place to embrace the manifestation of the world's newest tallest building. In this part, I distinguish between the potentials related to Dubai as a milieu and the potentials that affected the emergence of Burj Khalifa. The aim of this part is to prove that the effects of these potentials did not go beyond stimulating the milieu to receive the evolution of the world's newest tallest building. In other words, I show that their participation in the emergence of Burj Khalifa merely helped to produce Burj Khalifa, whereas the real evolution of the building as a technical object was an intrinsic evolution, which is the subject of the second part of chapter two.

The second part of chapter two is about Burj Khalifa as a technical object, which involves demonstrating the structural system as a technical object then showing how the other systems synergize the main direction of its emergence as the world's tallest building. As with the model of the Guimbal turbine, the argument comprises three steps: a full description of the system; then showing the concretization of the structural system as a technical object; and, finally, highlighting the main concepts. Also, this part includes outlining the meaning of the following considerations: the synergy of the systems in Burj Khalifa; the meaning of suppression as another type of synergy; the differentiations in the systems; and the ideas of function and specialization of the systems in the ensemble. Furthermore, the chapter endeavors to define the meaning of technical knowledge and technical perfection. Lastly, I end the chapter by looking at the role of architect/engineer.

Chapter One

Introduction to the Philosophy of a Technical Object

Chapter One

Introduction to the Philosophy of a Technical Object

The philosophy of a technical object involves a real challenge, particularly if we intend to employ its ideas in architecture. The multiplicity and diversity of the fields that Simondon covers in his philosophy about the technical object make us ruminate on which part we should explore and which concepts in his theory we should concentrate on. In this regard, determining initially the purpose of this study is crucial here to shape our visualization. Moreover, exploring Simondon's philosophy from the architectural view definitely reveals a different context. From this point of view, the aim of this introduction is to establish an epistemological framework for comprehending the meaning of the technical object in order to argue for Burj Khalifa as a technical object, which is the main target of this thesis.

The Technical Object and Simondon's Philosophy

We might agree that technology through its sets of values is what distinguishes our life at the present time, which obviously reflects its impact on the rhythm of our lives. Nevertheless, this agreement disappears when we talk about the essence of technology; and, perhaps, we stand puzzled before the question of what technology means and how we can grasp it. In same context, Simondon in his philosophy of technology expands this argument through adding the concept of the technical object to the equation and emphasizes the role that culture plays against the technical object.[27] Simondon goes on in his conceptualization to reassemble the disharmony between culture and the technical object as being similar as the behavior of the human being against a stranger.[28] He imputes that culture is unbalanced because it recognizes certain objects, such as the aesthetic object, and accords them their due place in the world of meanings, while it pushes back other objects, and particularly technical objects, to the unstructured world of things that have no meanings but do have a use, a utilitarian function.[29] Correspondingly, technical

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[27] Simondon, *On the Mode of Existence of Technical Objects,* 11.
[28] Ibid.
[29] Ibid.

objects become either commodities or automated things that have a low degree of technical perfection.[30] Simondon in his philosophy of the technical object endeavors to create an awareness of the significance of technical objects and at same time insists on the existence of a technical mentality which he describes as incomplete and unbalanced. It necessitates an initial attitude of generosity towards the order of reality that it seeks to manifest.[31] As a result, Simondon offers a dynamic theory of technology that would interpret a technical object not as a static being, but in its efficacy or operative functioning. Simondon, according to Chabot, "brought something new to philosophy: a way of thinking about the modes of existence of individuals and objects."[32] In short, Simondon's philosophy is a resolution of a crisis of humanity in its relation to the world of technics that resides in the opposition between the world of culture as a world of meanings and the world of technics considered exclusively from the angle of utility.[33]

Ideas Concerning the Meaning of the Technical Object

It might not seem strange that most scholars who have discussed Simondon's philosophy tend to depend on the frame of reference of concrete examples that Simondon offers in his dissertation to explain his ideas about the technical object. Perhaps this is attributable to the efficiency of those examples in delivering the concept of the technical object. It is striking also that Simondon tends to give precedence to visualizing ideas through models before framing the definitions of those ideas. In line with this, the Guimbal turbine has been selected as the master model in my endeavor to establish the knowledge frame of the technical object to discover what a technical object is.

The Guimbal Turbine: A Model to Grasp the Concept of a Technical Object

The Guimbal turbine, with which Simondon commences his journey into the technical object's realm in *On the Mode of Existence of Technical Objects*, is considered one of the

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[30] Ibid., 12.

[31] Simondon, "Technical Mentality", 1.

[32] Pascal Chabot, *The Philosophy of Simondon: Between Technology and Individuation,* translated by Aliza Krefetz (London: Bloomsbury Academic, 2003), 3.

[33] Combes, 58.

special examples that Simondon refers to predominantly to form a link between the notion and the practical applications that participate effectively in delivering the major ideas of technical objects easily. The turbine, according to Simondon, is immersed in a pressure water pipeline and coupled directly to a quite small generator contained in a housing filled with pressurized oil.[34] The water in which the turbine is immersed, as well as serving as a source of energy, becomes multifunctional through evacuating heat produced by the generator.[35] On the other side, Simondon indicates that the oil in the turbine also performs a multifunctional role:

> It lubricates the generator, insulates the gears, and conducts heat from gears to housing, where it is evacuated by the water. Also, it prevents water seepage through the axle-casing into the housing, because the oil pressure within the housing is greater than the water-pressure without. This very high pressure itself is [multifunctional]. It effects permanent greasing under pressure in the bearings, while preventing seepage of water if the bearings are not quite watertight.[36]

Simondon's interest in the Guimbal turbine focuses on two remarkable notes, which complete our visualization of the model: "before Guimbal's invention, it was unthinkable to place the generator in the water-pipe containing the turbine."[37] Simondon imputes this view to the method used to solve problems that makes the connection between water-tightness and electric insulation in one system a possible solution and allows for excellent cooling by means of both oil and water.[38] Secondly, concerning the relation between the water and the oil, for Simondon, "If the Guimbal generator were operated at full power in air it would quickly be ruined by heat, whereas there is no appreciable heat detected in its

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[34] Simondon, *On the Mode of Existence of Technical Objects,* 47.
[35] Ibid.
[36] Ibid.
[37] Ibid., 48.
[38] Ibid.

concentric double bath of oil and water, each of which is energetically stirred, the oil by generator rotation, the water by turbine turbulence."[39]

The technical description of the turbine's functions, which may seem complicated to some extent, conceals another interpretation of the reality, which is what Simondon calls the concretization of a technical object. He sees that the technical object of the turbine emerges into existence at the moment of invention[40] when the two sets, water and oil, of potentials click together. The potentials are coupled into a single continuous system when the synergy of the elements clicks in and a new regime of functioning has unexpectedly leapt into existence.[41] Here, Simondon determines a threshold that must be crossed by the system for the invention of the regime to exist. Indeed, he compares crossing the threshold to a quantum leap to a qualitatively new plane of operation.[42] At that moment, we see a new regime; the operation of the turbine is now self-maintaining without any external interference; it achieves a certain operational autonomy in which the potentials in the water and the oil have interlinked in such a way as to regulate the transfer of energy into the turbine and of heat out of it automatically. Furthermore, the potentials for both water and oil allow the turbine to continue functioning independently without the intervention of an outside operator to run or repair it.[43] Massumi explains the concretization of the technical object precisely when he says:

> Before the passing of the threshold, there were two discontinuous energetic fields. The oil and the water were separated by differentials of temperature, pressure, viscosity and pattern of movement. The respective energetic fields of the oil and the water were in a state of what Simondon calls 'disparity'. When the synergy kicked in, the disparity rolled over into an emergent continuity. The differentials

[39] Ibid.

[40] Simondon in *Course on the Invention and Development of Technologies* (*Cours sur l'invention et le développement des techniques)* defines an invention as "the discovery of a system of compatibility that constitutes a higher level on which previously incompatible and disparate elements can be integrated." Chabot, 20.

[41] Arne De Boever, 25.

[42] Ibid.

[43] Ibid.

> between the two fields are still there. But there is also something else, which has leapt into existence. There is a circularity between them, a recurrent feedback that has crossed a threshold to bring another plane of operation into existence. That plane of operation—of self-maintenance—is continuous.[44]

From the above it can be seen that Simondon defines the moment that the system crosses the threshold as the moment of invention where the two systems (water and oil), which are separated, synergize, leading to the emergence of a qualitatively new regime of functioning. What has appeared is a new regime that has different features and achieves a different function. The concretization of the turbine as a technical object confronts us with an essential question about the relation between the concretization, which leads to the emergence of the regime and creates a situation of the self-maintenance of the system, and understanding the cognitive schema as an abstract model in the mind of Jean Guimbal, who invented the turbine, that comes before the object and guides its construction. In fact, examining the model shows us that Guimbal managed to miniaturize key components to solve the problem of overheating. Simondon visualizes the ingenious solving of the problem through the schema of concretization which brings the invention into existence.[45] Thence, identifying the schema of concretization with the cognitive schema shows us, according to Massumi, that

> [t]he origin of the technical object is purely cognitive, and entirely internal to the human thinking subject. Human thought precognizes a solution, then externalizes it by finding a way to mould matter to the form of its pre-thought solution. The practical finding of that way would be the technical process: the set of mediating actions shepherding the abstractly thought object into concrete embodiment. Invention would move from the past of a thought, cognitively fully formed, toward the future of an embodiment materially repeating the

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[44] Ibid.
[45] Ibid., 24.

> original thought's abstract form. The relation of the technical object to its cognitive origin would be one of resemblance: conformity to a formal model.[46]

Nevertheless, this is not the entire story because what is extraordinary in this concretization is how we must think about the 'mentality' of the technical object, which is elucidated by Massumi as follows:

> The idea for the technical object is finally dependent for its effectiveness on the autonomous taking-effect of the relation. Either it clicks in or it doesn't. The designer can bring the two disparate fields of the water and the oil to the brink of relation, but the passing of the threshold belongs absolutely to their potential. The designer is a helpmate to emergence. He can put the pieces in place, moving through a linear series of steps progressing from the past of abstract conception to a present on the brink. But the passing of that threshold to invention depends on the potentialization of the elements presently in place as a function of their future. The new-found potential expresses itself as 'operative solidarity' between the elements, across the disparity of their fields.[47]

The illustration of the Guimbal turbine implicates some ideas that are considered key to completing the conceptual framework of the technical object, such as the associated milieu and concretization, which are discussed in the following sections.

Milieu and Associated Milieu

A technical object in Simondon's philosophy is strongly linked with the concept of milieu, and Simondon defines two influential milieus in the concretization of the technical object: the technical and the geographical milieus. The distinction between them can be realized by considering them as intrinsic and extrinsic factors. Simondon takes as a

[46] Ibid.

[47] Ibid., 26.

condition the cooperation between the two milieus to concretize a technical object: The technical object is at the point at which two milieus come together, and it ought to be integrated into both milieus at the same time.[48] Simondon considers the new milieu as an associated milieu that is not fabricated or, at least, not wholly fabricated. Furthermore, he sees the associated milieu as a definite system of natural elements surrounding the technical being and linked to a definite system of elements that constitute the technical being.[49] Thus, “the associated milieu is a mediator of the relation between fabricated technical elements and natural elements within which the technical being functions.”[50] With reference to the model of the Guimbal turbine, for Simondon,

> The ensemble constituted by oil and water in motion within and around the Guimbal turbine is of this sort. This ensemble is concretized and individualized by the recurring thermal changes that take place in it. The faster the turbine turns, the more the generator expels heat by Joule effect[51] and magnetic loss. But the faster the turbine turns, the more the oil in the rotor and water around the housing increase in turbulence and activate heat exchanges between rotor and water. This associated milieu is the invented technical object's condition of existence. [52]

In reality, a technical object cannot be formed part by part during the phases of a gradual evolution because the parts can exist only in their completeness or not at all, which makes the necessity of the associated milieu in the concretization of a technical object similar to making it viable.[53] Simondon shows that the concretization of the technical object in the Guimbal turbine is located by an invention that leads to assuming that the turbine’s

[48] Simondon, *On the Mode of Existence of Technical Objects*, 46.

[49] Ibid., 49.

[50] Ibid., 50.

[51] According to Wikipedia, “Joule heating, also known as ohmic heating and resistive heating, is the process by which the passage of an electric current through a conductor releases heat. The amount of heat released is proportional to the square of the current.” Wikipedia, “Joule heating,” *Wikipedia, The Free Encyclopedia*, June 1, 2014. http://en.wikipedia.org/wiki/Joule_heating (Accessed August 19, 2014).

[52] Simondon, *On the Mode of Existence of Technical Objects,* 50.

[53] Ibid.

adaptation is solved because a new condition has been established and makes this particular concretization possible. As well, he emphasizes that the adaptation is related to the associated milieu, which has already been established before the process of adaptation or the invention itself.[54] The question raised here is: What is the relation between the associated milieu and the structure of the system? There is a recurrence of causality between them, but it is unsymmetrical: the associated milieu plays an informational role that achieves a self-regulation of the regime.[55] Therefore, in the Guimbal turbine the water is the vehicle for information or for information-controlled energy that cools the housing. By contrast, without the recurrence of causality between the structure and the associated milieu each would proceed in its own direction and cause the regime to fail.[56]

Concretization is a process that causes the birth of an associated milieu. The invention brings into being a techno-geographic milieu, which in this case is the oil and water in the turbine. This techno-geographic milieu is a condition for the possible functioning of the technical object. Within this context, Simondon draws the human role into this process through the abstract theme, which is normally the design stage. Since these two milieus are two worlds that are not part of the same system and are not necessarily completely compatible with each other, the technical object is determined in some way by the human being's choice, which attempts to find the best compromise possible between the two.[57] Nonetheless, we have to take into account in visualizing the associated milieu the technical object's levels and how the concretization occurs at each level.

Levels of the Technical Object

A question may come to mind about the capability of implementing the idea of the technical object on different things overall. Practically, how we can understand the technical object in a simple tool such as a wheel and at the same time apply the ideas to

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[54] Ibid., 48.
[55] Ibid., 51.
[56] Ibid., 52.
[57] Ibid., 46.

sophisticated things such as buildings. Simondon solves this problem in his philosophy of the technical object through defining the levels of the technical object. This is considered one of the unique solutions in his theory since it goes beyond the problems faced by other theories that tied a uniform interpretation to one aspect.[58] In fact, Simondon develops a dynamic system for understanding the technical object, and it is made up of three levels: the element, the individual and the ensemble. Charissa Terranova believes that the dynamism of the distinction between the three levels lies in that "each component, decisive and unique, works together in the creation of an elastic and changeful fabric of culture and technology."[59] Likewise, she adds that "the terminology is quite self-evident, with the element representing the component of a given machine, the individual being the user, and an ensemble constituting a complex of machinery, as in a factory or laboratory."[60]

Understanding this system requires putting it into its historical context, which will make explicit the distinction between its levels and the role of humans in it. Chabot, in *The Philosophy of Simondon: Between Technology and Individuation*, determines the distinctive feature of the three kinds of technical objects. An element or technical element normally means either tools or instruments. "Tools (e.g. the hammer, the spear or the pen) exert an action on the world, so they require an energy source."[61] On the other hand, instruments (e.g. microscopes, stethoscopes or underwater probes) refine perception and must be integrated with a structure capable of decoding the information they provide.[62] Subsequently, both of them are considered as extensions of the human body: "the body acts as a source of energy or decoder of information."[63] Coupling elements in one object leads to the appearance of a technical individual, such as a machine. With technical individuals, the human body loses pride of place and becomes a servant of the machine.[64] For Chabot,

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[58] I am referring here to cybernetics. Simondon succeeds in offering a solution that deals with different situations of technological objects; but in in cybernetics theory, we find there is a one scheme that rules all the aspects.

[59] Charissa N. Terranova, *Automotive Prosthetic: Technological Mediation and the Car in Conceptual Art,* (Austin: University of Texas Press, 2014), 20.

[60] Ibid.

[61] Chabot, 35.

[62] Ibid.

[63] Ibid.

[64] Ibid., 36.

"[humans] keep its energy source fuelled and steer it into position; also the disproportion between the worker's body and the configuration of the machine is significant."[65] When different machines are combined and fed by the same power source, the ensemble appears as the third kind of development of the technical object. With the ensemble humans are excluded completely from the production process and their role is confined to that of adaptation. Consequently, the production process follows the rhythm of machines.[66] Simondon highlights the context of the appearance of a technical ensemble by noting the number of technical individuals that are mutually organized according to the result of their functioning and in such a way that they do not interfere with the conditioning of their specific functioning.[67] The importance of Simondon's classification of the technical object lies in two influential factors: the evolution and invention of the technical object in each level.

Simondon specifies the level of evolution of the technical object by confining the transmission of technicity within elements only:

> The element carries forward technical reality, whereas the individual and the ensemble contain technical reality without being able to transport and transmit it. They can produce and preserve but not transmit. Elements have a transductive property that makes them the true carriers of technicality, just like seeds that carry along the properties of a species and are to remake new individuals. Therefore it is in elements that we find technicality at its purest or, as it were, in a free state; in individuals and ensembles we can find it only in a state of combination.[68]

Creating the three levels (elements, individuals and ensemble) of the technical object comes through invention, which assumes different dimensions at each level. Invention at

[65] Ibid.
[66] Ibid.
[67] Simondon, *On the Mode of Existence of Technical Objects,* 57.
[68] Ibid., 63.

the element level is considered very difficult and is rooted in antiquity as is human evolution itself. Thus, searching for the genesis of the invention of the wheel, for instance, is similar to searching for all of humanity and its history.[69] Nevertheless, technical progress at this level is achieved through a dialectical relationship between mediation and autocorrelation. In other words, in a case such as that of the wheel, the mediation is the adaptation to the end terms, which is the path to be travelled and the load to be carried; and autocorrelation is the relation between the technical object and itself.[70] At the individual level, we assume that the inventor has an intuitive knowledge of the technical reality of the element; accordingly, invention, as I explained in discussing the Guimbal turbine, is achieved at the intermediary level between the concrete technical object and its abstract scheme as a prior existence. The associated milieu at this level is required to invent a technical object. Therefore, according to Simondon, individuals depend to some extent on the characteristics of the elements that they implement; but the invention of the technical object is composed of elements and an associated milieu simultaneously.[71] On the other hand, an associated milieu is what differentiates between individuals and the ensemble because it is undesirable in the technical ensemble. [72] However, it exists in technical individuals that compose the ensemble. At the ensemble level we are not talking about invention as at the element and individual levels, but we are talking about the coherence of a technical ensemble that comes fully into being when the ensemble is made up of individuals or sub-assemblies with the same level of relative individualization.[73]

The importance of the ensemble level in this research forces us to focus on the essence of the concretization of a technical object, which resides on the organization of functional sub-assemblies in the total functioning. Simondon sees that the redistribution of

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[69] Chabot, 10.

[70] Ibid., 10-11.

[71] Simondon, *On the Mode of Existence of Technical Objects*, 57.

[72] According to Simondon, at the ensemble level, it is necessary that no more than a single structure should be attached to a single associated milieu; otherwise, chance variations opposite in direction to the two structures non-synergistically attached to the same associated milieu could offset one another and fail to result in a regulatory reaction; structures attached to the same associated milieu should function synergistically. Ibid. 54-56.

[73] Simondon explains this situation clearly when he talks about the audiometer, where he discovered the necessity of separating individuals from one another, but at same time they have to be connected in a way that preserves their mutual independence. Ibid., 53-54.

functions involves a network of different structures where, in abstract as much as in concrete objects, each structure performs a number of functions.[74] In point of fact, there are two levels of functions; in the abstract technical object each structure performs only one essential and positive function that is integrated into the functioning of the ensemble, while in the concrete technical object all functions performed by the structure are positive, essential, and integrated into the function of the ensemble.[75] The remarkable thing in this regime is that the marginal consequences of the functioning that are eliminated or attenuated by correctives in the abstract object become positive stages in the concrete object and the functioning scheme incorporates the marginal aspects; thus, the consequences that are uninteresting or harmful become functional links.[76]

Concretization of the Technical Object

After the description of the milieu and the levels of the technical object, putting them into one context with a concretization of the technical object seems obligatory to provide a comprehensive realization of the technical object itself, which links initially with two main principles: the process of concretization itself and functional over-determination, which give it its consistency as the end-product of an evolution.[77] According to Simondon, authentic concretization consists in a convergence of functions within a structural unity where, in the abstract scheme, the parts of the system functionally act in such a manner that workers cooperate even when each worker does not know what the other workers are doing.[78] They work in a system one after another and even occasionally one against another without any effect on the main functioning of the system.[79] Thus, the concrete

[74] Ibid., 31.
[75] Ibid.
[76] Ibid.
[77] Ibid., 15.
[78] Henning Schmidgen, *Thinking Technological and Biological Beings:Gilbert Simondon's Philosophy of Machines*, Berlin: Max Planck Institute for the History of Science, 2004, 7.
[79] Ibid.

technical object is, for Simondon, "no longer fighting with itself, no secondary effect [interferes] with the function of its totality or remains outside of it."[80]

What is important here is to keep in mind that because the individuality of the technical object is modified and the outcome of a leap of invention, the only possible visualization of the genesis of a technical object is through referencing it to the technical species to which it belongs. In other words, throughout the technical species, a technical object is identified as an object in terms of the practical end it is designed to meet, as was discussed earlier in relation to the example of the Guimbal turbine.[81]

Concretization of a technical object is a translation of a scientific notion and principles that at the basic level are unconnected with each other. The abstract technical object is a physical translation of an intellectual system. Simondon in his philosophy of the technical object determines three stages in understanding a technical object. At the beginning there is an abstract technical object, which represents the design stage and is normally made up by the inventor. Then, a technical object is the stage at which an abstract technical object leaps through the threshold of invention and concretizes an authentic technical object. Simondon describes it as follows:

> The concrete technical object, that is, the evolved technical object, is quite the opposite in that it approximates the mode of existence of natural objects. It tends to internal coherence, and towards a closure of the system of causes and effects which operate in circular fashion within its boundaries. Further, it incorporates part of the natural world which intervenes as a condition of its functioning and, thus, becomes part of the system of causes and effects.[82]

In this light, we can understand a technical object as an intermediate place between a natural object, which is represented as a perfect concrete object, and the scientific

[80] Ibid.
[81] Simondon, *On the Mode of Existence of Technical Objects,* 6.
[82] Ibid., 40.

representation of a technical object, which is the abstract technical object.[83] A concrete object, which is the last stage, is a natural object in which all the functional parts are over-determined. Therefore, as Simondon sees it, the technical object is not a living being, but it is an individual.[84] It is clear that Simondon's philosophy focuses on a technical object not as a single being, but as a series or row of such beings. The concept of the technical object refers to the diagram or scheme and its material manifestations that, step by step, concretize the technical object. It is a unity of becoming.[85]

One thing remains in visualizing the concretization of the technical object, and it relates to the meaning of the improvements that occur. During the progress of the technical object there are two kinds of improvements that are added to the object: minor and major improvements. While major improvements increase in an essential way the synergy of functioning, minor improvements are harmful to a technical object because they can conceal the reality of a technical object or work against the essence of the technical being by using non-essential devices such as custom-made features that are added on and cause increasing loads on the performance of the technical object, as sometimes happens in the current designs of cars.[86]

The Inventor and the Technical Object

Simondon's philosophy offers a unique relationship between the invention of the technical object and the inventor. As we have seen with the Guimbal turbine, the inventor as a discoverer of the system acts as person who has an intuitive knowledge of the technicity of the elements that make up the whole system, which later concretize as a technical object.[87] Consequently, the inventor has a sense of the future and an imagination of the creative process itself—invention.[88] Chabot states:

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[83] Ibid.
[84] Schmidgen, 8.
[85] Ibid.
[86] Simondon, *On the Mode of Existence of Technical Objects,* 21-23.
[87] Ibid., 63.
[88] Chabot, 18.

> Simondon's inventor has a different conception of existence. He is not a man of conflict. He opposes nothing. He integrates. He doesn't seek to attain a specific goal, he attempts to find order and connection across the different worlds that he inhabits.[89]

The role of inventor is changed to coordinator when a technical object is concretized. For instance, in the ensemble of a machine that is grouped into two or more coherent sub-ensembles or individuals, exchanging information with each other occurs through the agency of the human interpreter as a coordinator, even though the exchange of information between them is direct. The inventor, for Simondon, "intervenes as the being who regulates the margin of indetermination so as to make it adaptable to the greatest possible exchange of information."[90] Simondon provides a comprehensive visualization of the inventor when he compares the role of the inventor to that of the conductor of an orchestra:

> The conductor can direct his musicians only because, like them, and as intensely as they, he can play the piece being performed; he slows them down or speeds them up, but is also slowed down or sped up by them; in fact, the group of musicians slows down and speeds up each member of the group through him, [and] for each of them he is the current moving form of the group in its very act of existing; he is the interpreter of all of them in relation to all. This is how man has the function of being the permanent coordinator and inventor of the [apparatuses] around him. He is among the [apparatuses] that work with him.[91]

Simondon's motivation for presenting a uniquely technological conception of humanity and of human problems is based on a conviction that there is nothing more natural to humans than technical activity. Thus, Simondon, for Graeme Kirkpatrick, "combines a positive appreciation of technology as something valuable in itself with an

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[89] Ibid., 20.
[90] Simondon, *On the Mode of Existence of Technical Objects,* 14.
[91] Ibid., 13.

understanding of nature."[92] Subsequently, "the inventor does not act against the world, but is better understood as working with elements of it to establish new kinds of coherence."[93] From this point of view, Kirkpatrick illustrates, "the inventor is, like the artist, a seeker at the margins of society who tries to establish a different relationship to the world, alternative points of connection that can ultimately create new worlds for us to experience."[94]

Through determining the character of the inventor in Simondon's philosophy, our voyage in establishing the conceptual frame of the technical object is completed, and it becomes evident what is meant by a technical object. Thus, we are ready to move on to the next chapter in which I discuss Burj Khalifa as a technical object.

[92] Chabot, ix.

[93] Ibid.

[94] Ibid.

Chapter Two

Burj Khalifa as a Technical Object

Figure 1: Burj Khalifa

Chapter Two
Burj Khalifa as a Technical Object

Burj Khalifa and the Concept of the World's Tallest Building

The construction mania for the world's tallest buildings[95] has become frequent during the last twenty years. It was clearly initiated with the Petronas Twin Towers in Malaysia (1998), declaring a frenetic race among the world's new economic centers to break the record for the world's tallest buildings. The slogan of supertall buildings has become part of their new character, as can be seen in cities such as Kuala Lumpur, Taipei, Shanghai, Jeddah and Dubai. This phenomenon has coincided interestingly during the past two decades with a dramatic shift in the distribution of tall buildings in the world from the west to the east and has become part of the mental picture of those cities in relation to their jungle of tall buildings, as in the case of Dubai.[96] Nevertheless, the inauguration of Burj Khalifa, which was known before its opening as Burj Dubai,[97] on Monday, January 4, 2010,

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[95] The term and title 'The World's Tallest Building' was announced in 1969 by the non-profit international organization Council on Tall Buildings and Urban Habitat (CTBUH), which sets the standards by which buildings are measured. Because of the dispute in 1996 about the criteria to determine the world's tallest building, as to whether the Petronas Towers or the Sears Tower was taller, the CTBUH defined four categories of ranked buildings as follows:

- Height of structural or architectural top;
- Height of highest floor;
- Height to the top of roof (removed as category in November 2009); and
- Height to top of any part of the building.

Though any building ranked as the world's tallest building will lose its rank after a while, the building continues to carry it for a specific period; for instance, Taipei 101was the world's tallest building from 1998 to 2010.

CTBUH, "100 Tallest completed buildings in the world," *Skyscraper Center*, http://skyscrapercenter.com/List/Tallest-100-Buildings (accessed August 3, 2014). Wikipedia, "List of tallest buildings in the world," *Wikipedia, The Free Encyclopedia*, August 3, 2014. http://en.wikipedia.org/wiki/List_of_tallest_buildings_in_the_world (Accessed August 3, 2014).

[96] According to CTBUH, there are more than 230 towers whose height exceeds 100 meters distributed over a specific area in Dubai. CTBUH, "All Tall buildings," *Skyscraper Center*, http://skyscrapercenter.com/create.php?search=yes&status_COM=on&status_UC=on&status_UCT=on&status_DEM=on (Accessed August 3, 2014).

[97] The name of Burj Dubai was changed to Burj Khalifa in the inauguration celebration, which was declared by the ruler of Dubai, Sheikh Mohammed Bin Rashid Al Maktoum. According to him, Burj Khalifa should carry the greatest name in the UAE, the name of the UAE's president, Khalifa bin Zayed. However, there are some who think that changing the name of the building to carry the name of the UAE's president was in

as a new world's tallest building has acquired an exceptional importance beyond its being merely a new world's tallest building. Over the two years that preceded its opening day, Burj Khalifa occupied a large amount of media attention locally and globally because of the global economic crisis that struck most of the world's economies at the end of 2007, causing a complete paralysis affecting many projects around the world. This tragic scenario in Dubai was among the roughest; hundreds of projects under construction were frozen or canceled; thousands of employees and workers were laid off. Dubai in that difficult time reached the edge of the abyss. In the midst of these events, Burj Khalifa, whose cost was estimated at $1.5 billion, was still under construction; its structure began looming as a giant on the skyline of Dubai. There was a general sense not only inside Dubai but also outside that work on the site could stop at any moment. This unprecedented attention to Burj Khalifa stemmed from a prevailing sense at that time of its being an extraordinary human achievement. For Antony Wood, "At the 'World's Tallest' end of the scale, the year 2010 witnessed an incredible feat, with the completion of the 828-meter tall Burj Khalifa in Dubai."[98] And he adds, "at no previous time in the history of the 'World's Tallest' has any building surpassed its predecessor by more than 68 meters (221 feet), but Burj Khalifa achieved a leap of an unprecedented 320 meters (1,050 feet) over the previous world's tallest, Taipei 101"[99] (Figure 2). To give a picture of this leap in height of the world's tallest building, for Wood, "the total height of Burj Khalifa is just five meters shy of the equivalent height of putting the Empire State Building on top of Petronas Towers (both formerly 'World's Tallest' buildings)."[100] Indeed, the inauguration of Burj Khalifa announced the birth of a new generation of the world's tallest buildings called megatall buildings,[101] which, structurally, instituted new principles to design and construct these kinds of buildings.

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reciprocation for the role of Abu Dhabi in protecting Dubai from collapse during the Global International Crisis that hit Dubai at the end of 2007.

[98] Wood, 3.

[99] Ibid.

[100] Ibid.

[101] According to CHTB, there are three categories to define tall buildings, which I explain in detail on page 48.

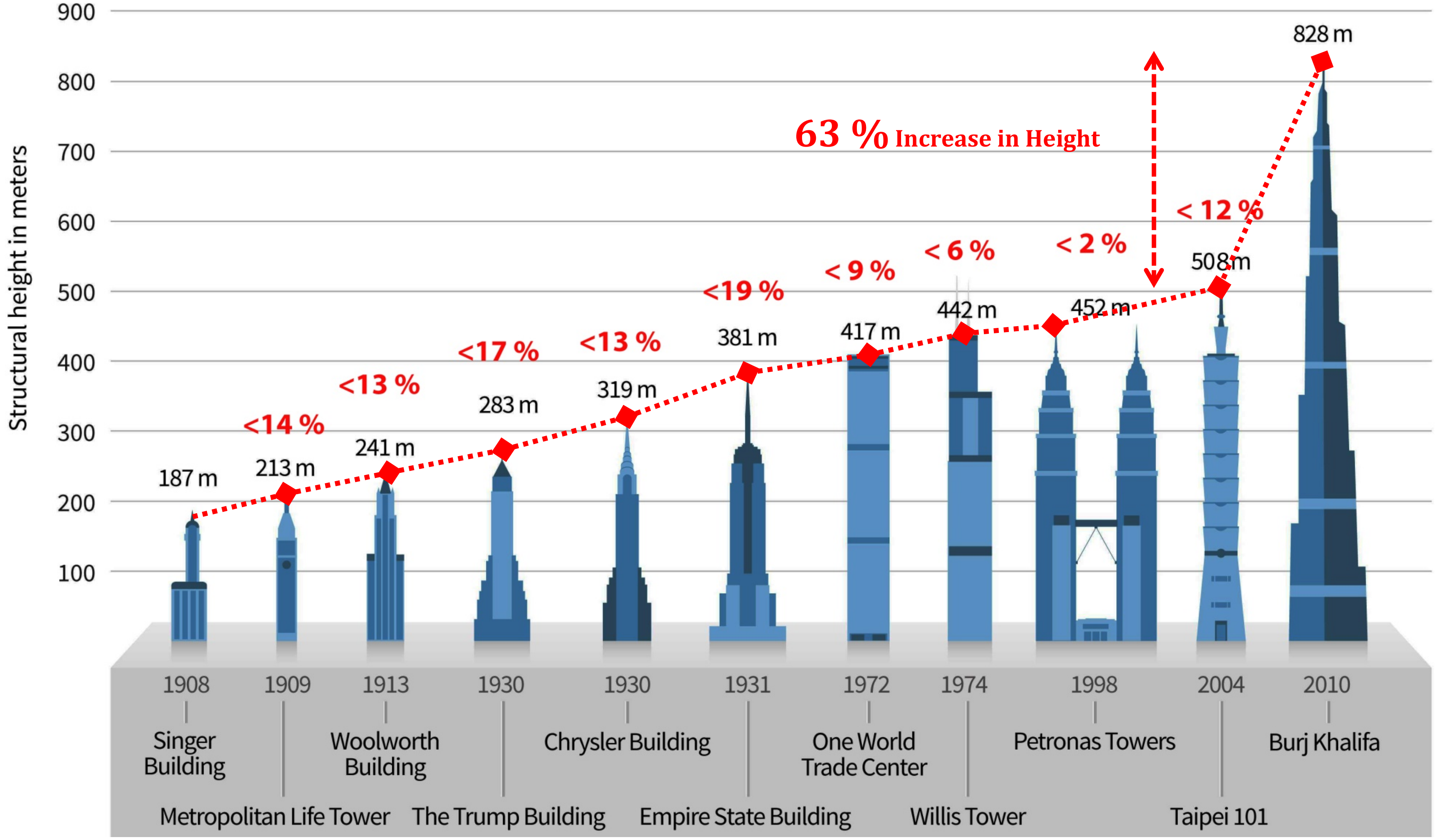

Figure 2: History of the increase in the height of the world's tallest buildings

Burj Khalifa represents a real challenge and test of the ability of human beings through the relation between nature and objects. Standing with its unique height and functioning for mixed-use purposes, it reflects a new approach of dealing with the topic of tallest buildings generally. Succinctly, it is an innovation by every means. Notwithstanding the multi-aspects of the innovations that can be seen in Burj Khalifa, technology occupies a big portion of that innovation if not the whole. As is the case in many other projects, perhaps summarizing and accounting for the technological successes as ends can offer a preliminary visualization of the technology in it. But, certainly, this offers an incomplete picture of its reality. In point of fact, technology in Burj Khalifa takes a different way, which we have not been used to discussing in regard to these kinds of buildings. In Burj Khalifa, technology manifests itself as a value through the concept of a technical object in which technology exceeds its instrumental meaning.

Revealing the technology in Burj Khalifa through this orientation guides us to see Burj Khalifa as a unique human accomplishment transcending the routine approach of evaluating it as being like any other building. Meanwhile, it makes Burj Khalifa rise to the ranks of unique human achievements, such as the Eiffel Tower or the Giza Pyramids. Therefore, the purely utilitarian outlook of Burj Khalifa, like that of any other building, drains the event of its value. I do definitely not assume here that Burj Khalifa should be excluded from meeting the key requirements of architecture, which mostly fall under the Vitruvius triangle. What I mean is that we have to see it within its context as the world's tallest ever man-made structure, which makes us realize the prerequisites and requirements that should be provided in normal buildings beyond the scope of the evaluation of this achievement. Indeed, this is a new approach to understating Burj Khalifa through the meaning of technology. In this respect, raising the following question, "What is the significance of arguing for Burj Khalifa as a technical object?" seems essential.

Burj Khalifa as the world's tallest building carries a different interpretation of technology. Through its concretization as a technical object, technology is demonstrated as a value excluding the merely instrumental view. Realizing Burj Khalifa as a technical object offers answers about its persistence, despite the financial distress that befell it, and its superiority, which exceeds that of the previous rivals significantly. Through its concretization as a technical object, Burj Khalifa as the world's tallest building has emerged as a technical leap exceeding the steady pace of the development of tall buildings generally and the effect of the economy on that development. Simultaneously, arguing for it as a technical object provides an answer to the role of the intrinsic and extrinsic influences that affected the evolution of Burj Khalifa and defines the position of the economy, politics and society in this evolution. This involves a distinction between an internal technical evolution and external influences that try to transform the object into a commodity. Identifying Burj Khalifa as a technical object means that we recognize it as an invention, which in turn does not refer to the traditional hylemorphic notion in which a person has an idea and then builds something that corresponds to that idea; rather, it is the birth of a new regime occasioned by the operation of recurrent causality involving the actual operation of the technical object itself.[102]

As a consequence, understanding Burj Khalifa as a technical object should be from the angle of the challenge, which is coupled with its height as the world's tallest building. Other systems are thus integrated mutually to achieve this goal. This orientation of determining the relationships of systems in the technical object contributes undoubtedly to demonstrating the main function of Burj Khalifa as a one entity, on the one hand, and the role of its systems that compose its structure, on the other hand. Completing this picture requires highlighting the potentials of the milieu and circumstances that surrounded the appearance of Burj Khalifa.

Burj Khalifa and Dubai: Reading in the Potentials of the Milieu

In the Government Summit Conference, held February 11-12, 2013, in Dubai,[103] the Ruler of Dubai, Sheikh Mohammed Bin Rashid Al Maktoum, initiated his first answer by

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[102] Simon Mills, "Concrete Software: Simondon's mechanology and the techno-social," *Fibreculture Journal*, (October 9, 2011), http://fibreculturejournal.org (Accessed February 26, 2014).

[103] In this meeting, Sheikh Mohammed Bin Rashid Al Maktoum was answering the questions that came through his website from the whole world. Thousands of questions arrived on his website, which were mostly on his vision about Dubai and the future of the city and why Dubai was taking this way of development. "Sheikh Mohammed's speech at the Government Summit on February 11, 2013," *YouTube*, 1:10 to 4:30 and 11:00 to 13:15, March 19, 2013, https://www.youtube.com/watch?v=YKH8doBCetg.

asking the audience: "Who does remember the second person who climbed the Everest summit? No one," he answered. "Who does remember the second person who landed on the moon? No one," he answered, again with emphasis. Then he added with emphasis, "A human strives to be number one since it is the best among all numbers … in fact, nobody knows who is after number one."[104] Later, when he was asked about the reason for building Burj Khalifa, he emphasized the idea of number one and digressed, explaining: "At the beginning, when the first concept of the project was presented to me, which was a building composed of 80 floors, I rejected it and told them I want in this place the tallest man-made building ever constructed."[105] Through observing the development of the lifestyle of Dubai, it seems evident that this passion is not confined to the construction field, but includes all Dubai life. For instance, one of the stark examples of such an orientation is Emirates Airlines.[106] What concerns us here is that when Sheikh Mohammed showed his desire to construct the world's tallest building in Dubai, would he have known at that time—about 2002—whether Dubai could do it or not? Would Dubai have the capacity to accept this challenge? Meditating on the events that followed the Dubai leader's aspiration shows that the picture of the project was ambiguous. Everything was vague: what would that building be? How many floors would the building consist of? And, what would be its materials? But what is striking here is that the height of the project, which was the decisive factor in determining its identity according to Sheikh Mohammed, was not clear at that moment. In other words, what was meant by the world's tallest building? Would it be higher by one or one hundred meters than Taipei 101, the world's tallest building at that time, or something else? In spite of the vagueness of the project at that time, Dubai, or particularly the

[104] Ibid.

[105] Ibid.

[106] Emirates Airlines became in a very short time one of the best airlines in the world. Currently, Dubai International Airport, which is the center of Emirates Airlines, is on track to be the world's busiest airport by early 2015. Adam Bouyamourn, "Dubai International Airport on track to be the world's busiest by early 2015," *The National Business*, July 27, 2014, http://www.thenational.ae/business/industry-insights/aviation/dubai-international-airport-on-track-to-be-the-worlds-busiest-by-early-2015 (Accessed July 12, 2014).

Downtown Dubai[107] area, was the sole determinant that appeared obvious as the site for the world's tallest building.

Dubai and Potential Energy

In *Gilbert Simondon and the Philosophy of the Transindividual,* Muriel Combes mentions that "a physical system is said to be in metastable equilibrium (or false equilibrium) when the least modification of system parameters (pressure, temperature, etc.) suffices to break its equilibrium."[108] What is important in her description is her illustration of the pre-individualized being of ice; she imagines the crystallization of super-cooled water to ice. Continuing the liquid state of water even at temperatures below the freezing temperature places the system in a high situation of metastability and stimulates it against external effects. If an adulterant is thrown into the water, the water will freeze immediately, as if we were watching a clip of the making of the ice in fast motion. For Combes, "the least impurity with a structure isomorphic to that of ice plays the role of a seed for crystallization and suffices to turn the water to ice."[109] It is quite evident that the system (water) before the crystallization process is a metastable milieu oversaturated with potential energy, which works as potential squaring the system up to crystallization while the adulterant is what spurs the system to start the crystallization process. From the above, it is clear there are two factors to achieve the crystallization process: the potentials of the milieu and of the spur—the adulterant—which impels the system to leap.

As I indicated in the first chapter when I discussed the milieu, Simondon distinguishes between two kinds of milieus: geographical and technical. Although much

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[107] Downtown Dubai, previously known as Downtown Burj Dubai, is a large-scale mixed-use complex under development in Dubai. Wikipedia, "Downtown Dubai," *Wikipedia, The Free Encyclopedia* March 29, 2014. http://en.wikipedia.org/wiki/Downtown_Dubai (accessed August 8, 2014). In fact, there is no relation to the common meaning of downtown, which means the heart and higher density of a city. Dubai in this new development tried to create a new heart of the city—a modern downtown. Although there was no official name for the downtown of Dubai before the construction of Downtown Dubai, there is a traditional area which is unofficially the downtown of Dubai. It is located on Dubai Creek and includes older areas such as Nief and Al-Shindagha.

[108] Combes, 3.

[109] Ibid.

could be said for the efficacy of this distinction in other fields, there seems to be much overlap when we want to implement it for buildings. Furthermore, there are other potentials, which do not belong to geographical or technical milieus but that played influential roles in the emergence of Burj Khalifa. Arguing for the milieu in its comprehensive meaning offers a wide perspective to distinguish potentials that participated in the coming into being of Burj Khalifa as a building from other potentials that were involved directly in its concretization as technical object. [110] In reality, I depict these two kinds of potentials as two different powers: horizontal, which aims to concentrate potentials in one place—in Dubai and specifically in Downtown Dubai; and vertical, which is related directly to the tallest buildings and aims to provide new trends of technicality. Though there is an essential distinction between them, there is also an intersection zone that reveals a kind of overlap.

Horizontal Power: Oversaturating the Place

Not surprisingly, the appearance of the world's tallest building in Dubai was not far-fetched at the beginning of the third millennium, not because there was no other eligible place in the world that could embrace world's tallest building, but because Dubai at that time, or specifically after the events of September 11, became prepared to give birth to the world's tallest building. Dubai began taking serious steps towards establishing its structure and adopted strategies to change it from an unknown city to a city ready to receive the most famous building in the world, the world's tallest building. This shift carried potentials that enhanced the emergence of Burj Khalifa, and they can be epitomized as follows:

I. Return of Migratory Capital

The subsequent transformations on the heels of the September 11 affected the general atmosphere of life in the United States and Europe and especially in the investment fields. It was seriously considered for much of the capital belonging to the Middle Eastern

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[110] Under the heading of milieu, there are a number of factors that could have influenced the emergence of Burj Khalifa, and listing all these factors, whether as a geographical or technical milieu for instance, the climate or the construction techniques, seems impractical. Therefore, I avoid discussing them and am limiting my argument to the factors that affected directly the emergence of Burj Khalifa as the world's tallest Building.

countries to leave the United States and Europe and find alternative places for new investments; one of those alternatives was to return the capital to its countries of origin—the Gulf States.[111] But what made Dubai the favorite receptacle was its capability of absorbing the returning capital without any conditions. The milieu was ready to receive and re-inject capital into the market within a short time. According to an Arabian Money website, "after 9/11, there was a massive repatriation of Arab capital from the United States for fear of seizure by the enraged nation. The in-flows of cash into the Gulf States were prodigious. One estimate for Dubai alone was $300 billion."[112] Concentrating the huge amount of capital in Dubai accelerated its entering into the challenge race among cities without any obstacles. Consequently, projects classified as fancy projects began appearing to be reality during that period, for example, Burj Al-Arab, Jumeirah Palm Island, Dubai Ski, and Dubai Mall (Figures 3-6). In the midst of that momentum of extraordinary projects, the idea of constructing Burj Khalifa (Figure 7), which was estimated at $1.5 billion, appeared as a continuity of Dubai's trend toward achieving its individuality.

II. Real Estate as an Approach for Development

Although the UAE possess the seventh largest proved reserves of oil in the world at 97.8 billion barrels, Dubai, contrary to what people may think, has only about 4 per cent of those reserves—approximately 4 billion barrels.[113] Dubai's government recognized early on that depending on oil as a main source of national income would be a restriction on its future aspirations. One of the strategic decisions adopted by the government was to enhance the service and tourism industries, which made real estate and project developments earn extra value. This orientation was reflected clearly in the construction industry, resulting in a boom in real estate at the beginning of 2001. As a result, the city changed overnight into looking like a huge construction site with thousands of pieces of

[111] Gulf States designates the eight Arab countries located on the western side of the Gulf of Arabia, namely, Kuwait, Bahrain, Iraq, Oman, Qatar, Saudi Arabia and the United Arab Emirates (UAE).

[112] GCC Economics, "How 9/11 caused an economic boom in the Gulf Oil States from 2003-8," *Arabian Money*, September 11, 2011, http://www.arabianmoney.net/gcc-economics/2011/09/11/how-911-caused-an-economic-boom-in-the-gulf-oil-states-from-2003-8 (Accessed June 7, 2014).

[113] EIA, "United Arab Emirates," *Independent Statics and Analysis, U.S. Energy Information Administration*, December 4, 2013, http://www.eia.gov/countries/cab.cfm?fips=tc (Accessed June 12, 2014).

Figure 7: Burj Khalifa

Figure 3: Burj Al-Arab

Figure 4: Jumeirah Palm Island

Figure 5: Dubai Ski

Figure 6: Dubai Aquarium in Dubai Mall

construction equipment. For instance, at the beginning of 2006, which witnessed the raising of the structure of Burj Khalifa on the Dubai skyline, there were almost $300 billion worth of projects underway and about 30,000, or 24 per cent, of the world's 125,000 construction cranes were working within the limits of Dubai's authority.[114]

From another point of view, there is a hidden factor related to the specialty of real estate in Dubai which is invisible to many people dealing with the phenomenon of tall buildings; it is the cost of land. Historically, tall buildings have been connected with the value of land, particularly if we look to the beginning of tall buildings in high density areas such as Manhattan. There is a direct proportion between the height of buildings (number of floors) and the cost of the land. On the contrary, this fact seems irrelevant in the case of Burj Khalifa, where the whole project's land—the Downtown Dubai land—was granted to Emmar, the main developer of the Downtown Dubai area and Burj Khalifa, by the Dubai government. As a result, the financial burdens that result from the high cost of land were nonexistent there. Rather, there are those who believe that one of main reasons for the development of Downtown Dubai and the construction of Burj Khalifa was to increase the value of that area, which seemed obvious later from the high rates of rent and sale properties in that area.

III. When Fantasy Becomes the Theme of the City

Dubai is a desert city with a tropical desert climate, which makes it a hot and humid place for most of the year. According to meteorological data, the average temperature in summer is around 40 °C and overnight falls to around 30 °C with humidity averaging over 60 per cent.[115] This extreme weather makes the tendency to establish an economy based on the service and tourism industries either madness or a dream. However, we may be surprised when we cannot find available spaces in Dubai's hotels in July and August when the temperature exceeds 50° Celsius in the day time. The secret lies in its approach. Dubai

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[114] "Dubai has 30,000 construction cranes," *Gulf News*, June 18, 2006, http://gulfnews.com/business/construction/dubai-has-30-000-construction-cranes-1.241346 (Accessed July 5, 2014).

[115] "Climate", *Dubai Airport*, July 18, 2015, https://services.dubaiairports.ae/dubaimet/MET/Climate.aspx (Accessed July 18, 2015).

has taken a special approach to overcome its geographical limitations through building a fantasy world in all aspects, starting from the first moment a person sets foot inside the Emirates, the official airlines of Dubai.[116] We can feel this spirit manifestly also in clips from the movies in which Dubai was the background, such as *Code 46* and *Mission Impossible*, which particularly used Burj Khalifa as the location for filming (Figures 8-9). This approach to dealing with geographical difficulties is reflected clearly in the nature of Dubai's projects and its themes. For example, the Falcon City is a revisualization of the Seven Wonders of the World, and Ibn Battuta Mall re-creates the journey of one of the famous Arab explorers, Ibn Battuta, in the 14th century (Figures 10-11). In the same context, Burj Khalifa as a concept was not far from this approach, which appears clearly in the admission of Adrian Smith, the architect of Burj Khalifa, of the influence of the gleaming towers of the Emerald City in *The Wizard of Oz* rising in the midst of poppy fields. He adds, "I just remembered the glassy, crystalline structure coming up in the middle of what seemed like nowhere."[117] Although this is an imaginative picture of the concept of Burj Khalifa, it shows a high level of rational thinking compared to other projects and its fantasy element stems from Burj Khalifa's being the world's tallest building.

IV. Legislation and Codes

The nature of the political system in Dubai, which is similar that of the other six states that comprise the UAE, makes decisions often linked to the supreme authority of the ruler. As a result, the vision of the ruler represents the main guidance of the city to a large extent.[118] This is the one of the influential factors that made Dubai reach its current status quickly. It has created different levels of dealing with difficulties, which can face any

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[116] There are many criticisms that have targeted at the UAE and specially Dubai because the United Arab Emirates was reported as the country with the largest ecological footprint per person in the world, even before the USA. "United Arab Emirates," *Global Footprint Network*, July 4, 2014, http://www.footprintnetwork.org/en/index.php/GFN/page/uae_case_story/ (Accessed July 18, 2015).

[117] Robyn Beaver, ed., *The Architecture of Adrian Smith, SOM: Toward a Sustainable Future* (Victoria, Australia: Images Publishing, 2007), 29.

[118] In this context, the book *My Vision: Challenges in the Race for Excellence Future* by Sheikh Mohammed Bin Rashid Al Maktoum can be a guide to grasping the main approach of his aspiration for the future of Dubai. Mohammed bin Rashid Al Maktoum, *My Vision: Challenges in the Race for Excellence Future* (Dubai: The Dubai Government Media Office, 2012).

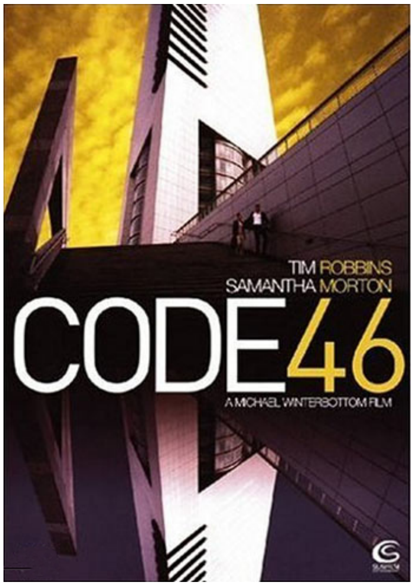


Figure 8: The poster of the film *Code 46*, shown in the background the Emirates Towers

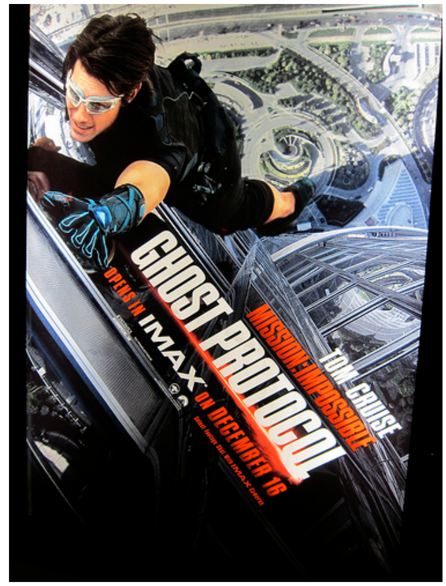
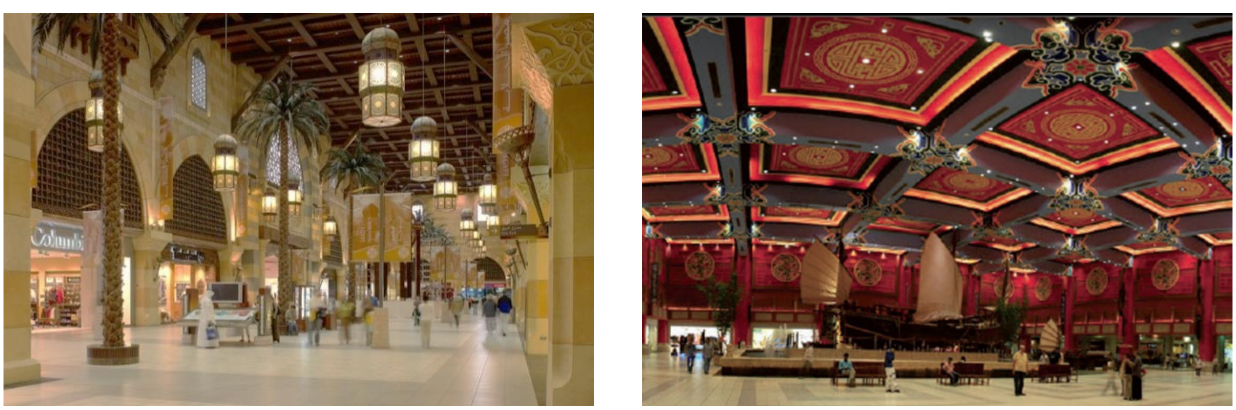


Figure 9: The poster of film *Mission Impossible* shows Tom Cruise climbing Burj Khalifa

Figure 10: View of the Falcon City showing the Eiffel Tower and Giza Pyramids



a. Egypt Wing

b. Chinese Wings

Figure 11: Two wings in Ibn Battuta Mall

project, whether from government or municipality. Dubai, or specifically its ruler, Sheikh Mohammed, has shown an unrivalled flexibility in dealing with strategic projects that require special exceptions. From this point of view, even though Dubai's municipality is the highest executive foundation when it comes to issuing project permits, there are other executive foundations that work independently. For instance, when Dubai decided to develop what is known as TECOM,[119] a new authority carrying the same name (TECOM) was instituted and became responsible for issuing construction permits for new projects, even though those projects did not follow completely the main regulations of the Dubai municipality. This way of dealing with special projects has effectively accelerated the pace of constructions in new development areas and freed projects from routine constraints. Similarly, Downtown Dubai with its heart Burj Khalifa, which is located about 20 minutes from the main office of the Dubai municipality, was excluded from the municipality's authority and is managed by Emmar, which, extraordinarily, is the owner, developer and authority all at one time. Perhaps, this mixture of roles would sound strange or even illegal in other parts of the world. But what makes it acceptable is that Emmar is a quasi-governmental institution, so it reflects the vision of the government, which is synchronized with its eagerness to achieve high standards of the works, surpassing the standards of the municipality itself, as in case of Burj Khalifa. The work of Downtown Dubai and Burj Khalifa was achieved according to the master plan that was prepared by Emmar. If we look at the work of Emmar on Downtown Dubai and Burj Khalifa carefully, we find that Emmar established a competent authority and employed highly qualified people in all specializations who could deal with this kind of project, which, technically, the Dubai municipality did not have. Objectively, Emmar succeeded in creating a balance between the speciality of the project and the requirements of the municipality in a manner that prevented the project from having a number of problems that could have affected its proceeding, for instance, when there were no regulations or codes for safety and fire issues, as I will explain later. Afterwards, the authority over Downtown Dubai and Burj Khalifa was returned to the Dubai municipality when the main construction works were finished.

[119] There are many other authorities that work according to the same procedures, such as Dubai Silicon Oasis, Dubai Investment Park (Dip), and Jebel Ali Free zone.

On the other hand, Dubai has embarked on laws that have contributed mightily to pushing investment in real estate forward; legislation and laws have been issued to organize property ownership and foreigners' residence rights, which have opened Dubai widely to a new wave of investments in real estate and enhanced its leading position in construction. This is demonstrated unequivocally by the fact that 900 private residential apartments, the total residential units in Burj Khalifa, were sold out within eight hours of being put on the market.[120]

V. Dubai is an Accessible City

During the first decades of the 21st century, Dubai was able to build its reputation as an accessible city among those cities considered as destinations for work and tourism. Roland Marchal thinks that there are three factors that have brought Dubai to this position: easy access to visas, the position of Dubai as a center of air transportation, and, lastly, the easiness of the security arrangements at the border.[121] These advantageous possibilities within a wider area classified as politically unstable made Dubai a primary destination for those looking for an opportunity to work and live in a stable and safe place. Dubai, today, has one of the highest rates in the world of diversity of foreign nationalities—202 different nationalities exist in the labor market.[122] This applies too to the employment structure in projects; in Burj Khalifa, for instance, at the peak of construction, over 12,000 workers and contractors were on site every day, representing more than 100 nationalities.[123]

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[120] CM Raper, "Engineering Milestone: World's Tallest Building," *Engineering and Technology*, November 8, 2013, http://engineering-and-technology.blogspot.ca/2013/11/worlds-tallest-building.html (Accessed July 18, 2014).

[121] Marchal, 104-106.

[122] "202 nationalities in labour market," Khaleej Times, August 25, 2006, http://www.khaleejtimes.com/DisplayArticleNew.asp?section=theuae&xfile=data/theuae/2006/august/theuae_august735.xml (Accessed July 18, 2014).

[123] "Construction," *Burj Khalifa*, http://www.burjkhalifa.ae/en/TheTower/Construction.aspx (Accessed July 2, 2014).

Vertical Power: Stairway to the Sky

There is no doubt that the topic of tall buildings entered a major turning point at the beginning of the twenty-first century through two dimensions: first, the inevitability of change, which coincided with the events of September 11, and the subsequent changes in designing tall buildings generally. Secondly, there is the connection with technology, which provides tools to extend more vertically. In spite of the clear separation between these two levels, in reality, there is a reciprocal relation between them. What we see as changes in the design of tall buildings, as a natural result of the events of September 11 and what followed, are in essence a cause for the events whereby technological development is represented in tall buildings as an icon. The most prominent features of the trends at this level are as follows:

I. Changes on the Map of the Tallest Buildings

Through examining the detailed list of the 100 tallest buildings in the world, which is issued by the Council on Tall Buildings and Urban Habitat (CTBUH) periodically, it can be seen that there is a shift of the density of distribution of tallest buildings from the west to the east and the Middle East. Increasing the density of the tallest buildings in specific areas in the world plays an essential role in stimulating the appearance of new tallest buildings in those areas (Figures 12-13). It generates a momentum pushing the milieus in those areas for more height. We can see this when we examine the number of tall buildings in the Middle East that preceded Burj Khalifa and at the same time how the momentum of milieus increased when Burj Khalifa was completed to push for a new world's tallest building, the Kingdom Tower, in Jeddah, Saudi Arabia, which will be over 1,000 meters in height and exceed Burj Khalifa by approximately 18 percent.

II. Increase in Height and Change in Classification

Continuing with the last point, the height of tall buildings has started increasing remarkably. The average height of these buildings has doubled during the last eight decades and jumped by 13 percent in the period 2000-2010 alone. This trend in increasing the height of tall buildings has been combined with a change in the definition of the tall

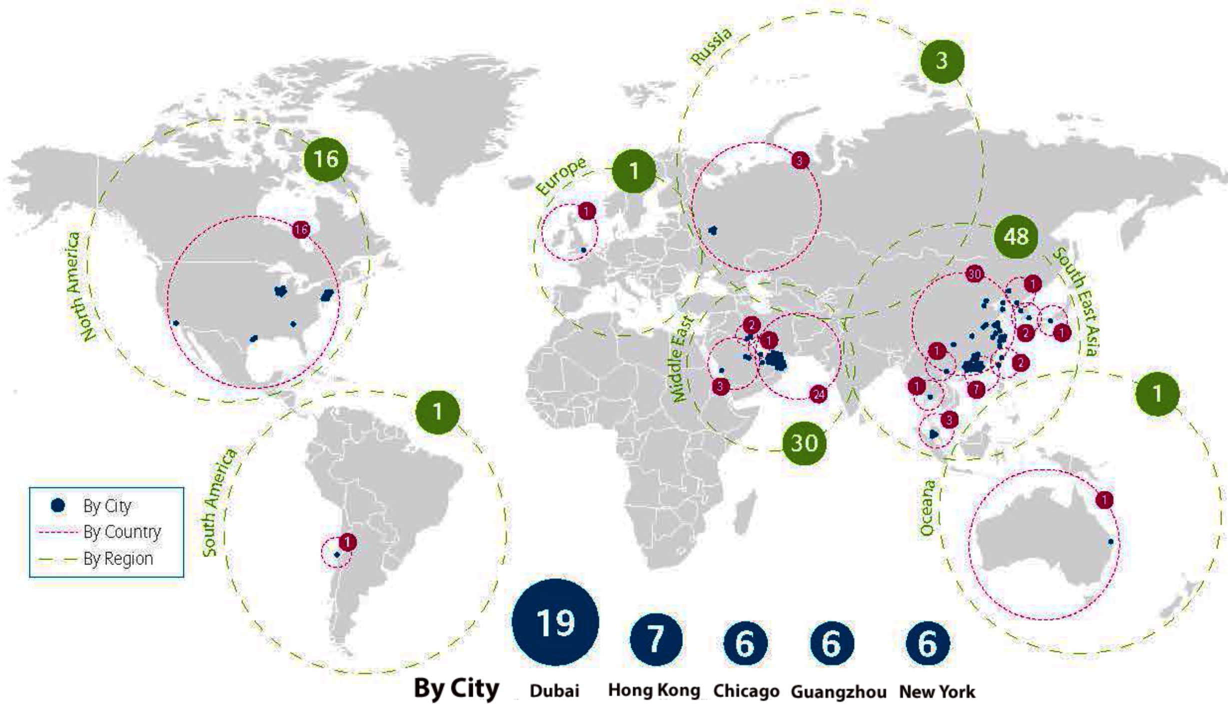

Figure 12: Location of the 100 tallest buildings in the world

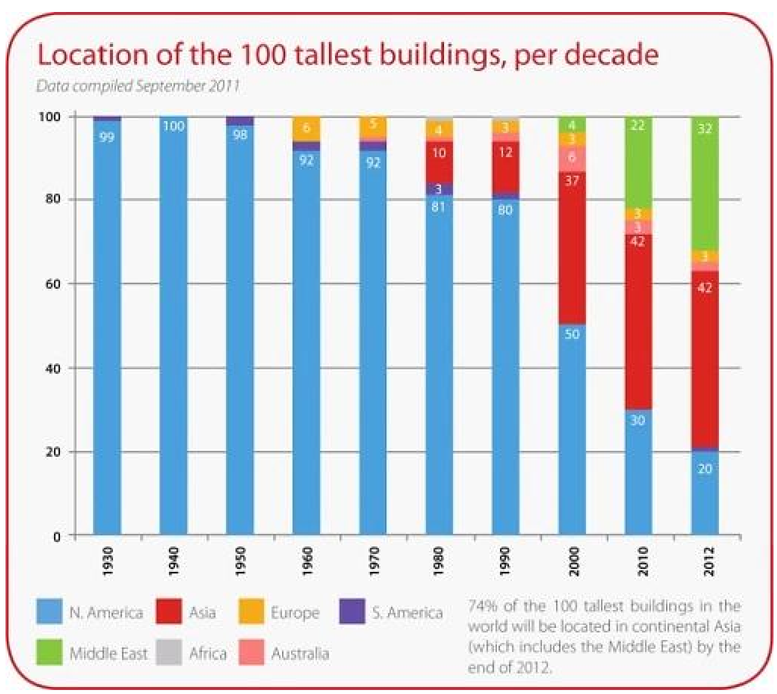

Figure 13: Location of the 100 tallest buildings per decade

building. Although Frank Lloyd Wright's concept of the one-mile tower appeared in 1956, the classification of tall buildings did not change. All tall buildings were defined using the same terminology: tall buildings or skyscrapers. But with the appearance of buildings exceeding the threshold of 600 meters in height, it became necessary to re-distinguish tall buildings. According to CTUBH, there are three categories of tall buildings: tall buildings, which are normally more than 100 meters and less than 300 meters in height[124]; supertall buildings, which are between 300 to 600 meters in height; and megatall buildings, which are buildings that exceed 600 meters in height (Figure 14). In effect, this category has brought the race for tall buildings to a new stage because the category of tall building becomes part of its value and some few meters become crucial in the transition from one level to another. Today, Burj Khalifa and Makkah Clock Royal Tower Hotel (MCRHT) are the only buildings in the world that are categorized as megatall buildings, although MCRHT's height is 601 meters—only one meter above the threshold. On the other hand, we find that Taipei 101 was excluded from being a megatall building despite the fact that its height reaches to 508 meters.

III. Changing the Function of the Tallest Building

Historically, tall buildings were restricted firmly to a unitary function, which was mostly commercial, as in the case of office buildings. Perhaps, this belongs mainly to the field that tall buildings were developed in. Technically, this orientation in the usage of tall buildings made their evolution, especially in the matter of height, follow a steady rhythm, which is part of the reason why there was not a real leap in the height of tall buildings.[125] But with the approach of the third millennium, there was an alteration in the function of tall buildings from unitary to multi-function, or what is commonly known as mixed use. As well, the residential usage enters as a main player in the equation of the success of tall

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[124] According to the Emporis website, "A high-rise building is a structure whose architectural height is between 35 and 100 meters. A structure is automatically listed as a high-rise when it has a minimum of 12 floors, whether or not the height is known. If it has fewer than 40 floors and the height is unknown, it is also classified automatically as a high-rise." "High-rise building (ESN 18727)," *Emporis*, http://www.emporis.com/building/standards/high-rise-building (Accessed June 2, 2014).

[125] I explained earlier that Burj Khalifa is the first world's tallest building to exceed by more than 60 per cent extra height the former world's tallest building.

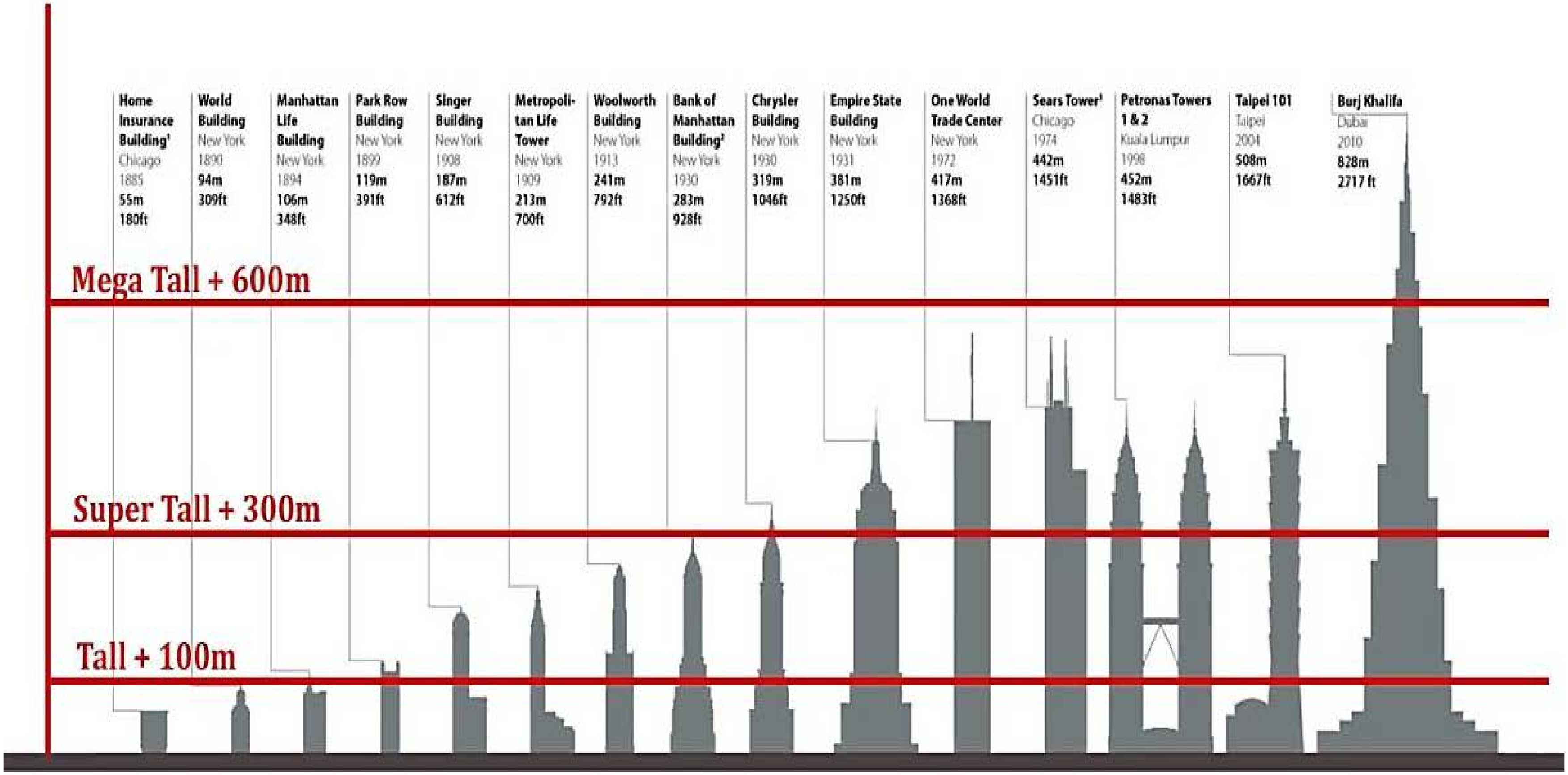

Figure 14: Classification of tall buildings

buildings. The key to this change lies in offering a technical solution to the matter of height in tall buildings, which seemed intractable with the unitary function. As is known, there are different requirements of office spaces compared to residential spaces, which are represented mainly by the number of occupants. For instance, in Burj Khalifa, according to James W. Fortune, the "3-million-square-foot tower is planned to house about 4,000 tenants and visitors, compared to about 15,000 office tenants that would be projected to occupy the space, had it been designed exclusively for office tenants."[126] This difference affects the organization of the internal spaces and fire and safety requirements. The nature of the residential spaces, which are usually small and segmented, makes dealing with higher floors, which is the main issue in tallest buildings, more flexible and maneuverable to overcome in relation to the serious issues of higher floors. Practically, this change in function in upper floors made them compatible within the standards of human needs. For Antony Wood, "if the creation of the 'World's Tallest Building' is the primary motivator, then it is easier to do it with a function that will put fewer people in continual occupation at the top of the tower and thus reduce the size of the floors needed to house them and the services needed to support them."[127] Coupled with this advantage, the residential function in tallest buildings, as hotel or private units, has made tall buildings an open area to the public; anyone can enter them or live in them, which has contributed to their publicity as attractive projects. Moreover, the ambition of constructing these kinds of buildings finds a stable ground in the relationship between the developer and the owners of the residential units or the operator of the hotel. In the office building, for example, the feasibility of the areas comes for the most part after completing the construction work on the building and renting the spaces. Further, there is a margin to keep the building empty despite its completion because of the situation of the market, which means extra burdens on the developer's shoulders. On the contrary, the residential units are owned by individuals who, in general, pay the value of the property during the implementation phase in the form of periodic installments. In the same context, we find that the hotel as an investment has some flexibility and is subject to different conditions. All these points undoubtedly describe the

[126] James W. Fortune, "Project Spotlight: Burj Khalifa," *Elevator World India* 3, no. 4 (2010), 47.
[127] Wood, 3.

expansion using the residential and mixed use in tall buildings during the last decade (Figure 15).

IV. The Evolution in the Materials

Despite the marked changes in using materials in tall buildings, whether for the interior or the exterior elements, this has not been the influential factor in their development. What is influential in this equation is the materials used in the construction of the main structure of the tallest buildings. The change in the structural materials shows a conversion to using concrete instead of steel. According to CTBUH, "all-steel buildings in the 100 Tallest have dropped from 90 percent as recently as 1970, to 23% now (September 2011) in favor of concrete or composite structure"[128] (Figure 16). CTBUH imputes this diversion towards concrete/composite structure in the world's tallest buildings to sufficient concrete technological expertise over steel in the new places of tallest buildings, in the Middle East for instance.[129] In addition, concrete as a construction material has many advantages, such as its cost as a material and in labor, which are lower than steel. Moreover, concrete is more efficient as a fire-rated material and acoustic insulator than steel, particularly with the new functional trends in tall buildings for mixed use and as residences, for the purpose of which concrete seems optimal. Structurally, concrete more adequately handles damping of movement, especially in residential usage, and transfer of vertical loads.[130] Nevertheless, this preference for using concrete rather than steel does not mean that it is used absolutely because there is still a wide range of advantages for using steel exclusively on the top of the tallest buildings where concrete is structurally inappropriate.

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[128] CTBUH, "Recent Global Trends in Tall Buildings: Location, Function & Structural Material," *CTBUH 2012: Asia Ascending*, http://www.ctbuh.org/Home/FactsData/TrendsinTallBuildings/tabid/2776/language/en-US/Default.aspx (Accessed August 01, 2014)

[129] Wood, 3-7.

[130] CTBUH, *Recent Global Trends in Tall Buildings: Location, Function & Structural Material.*

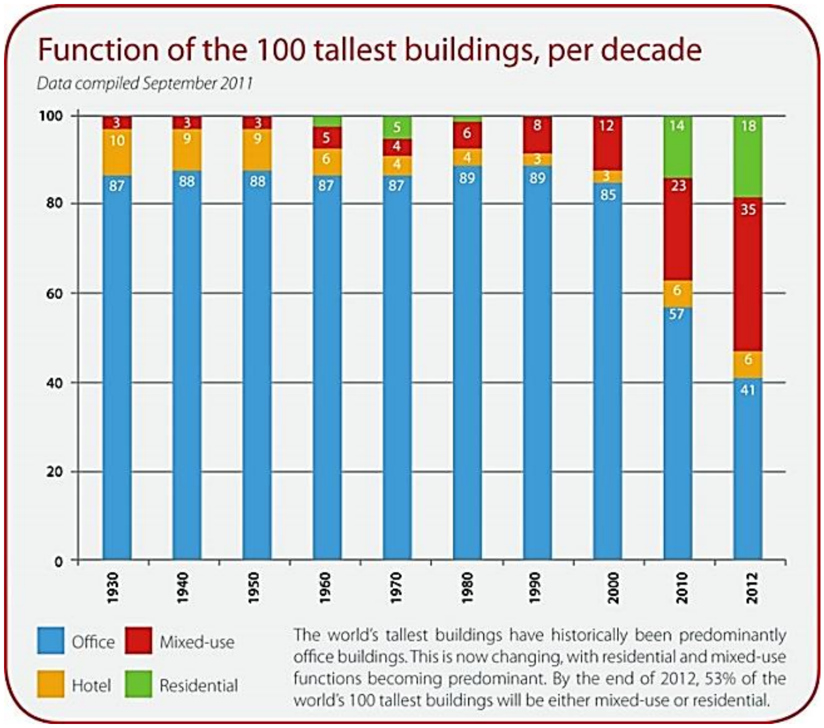

Figure 15: Changes in the function of tall buildings in the last decades

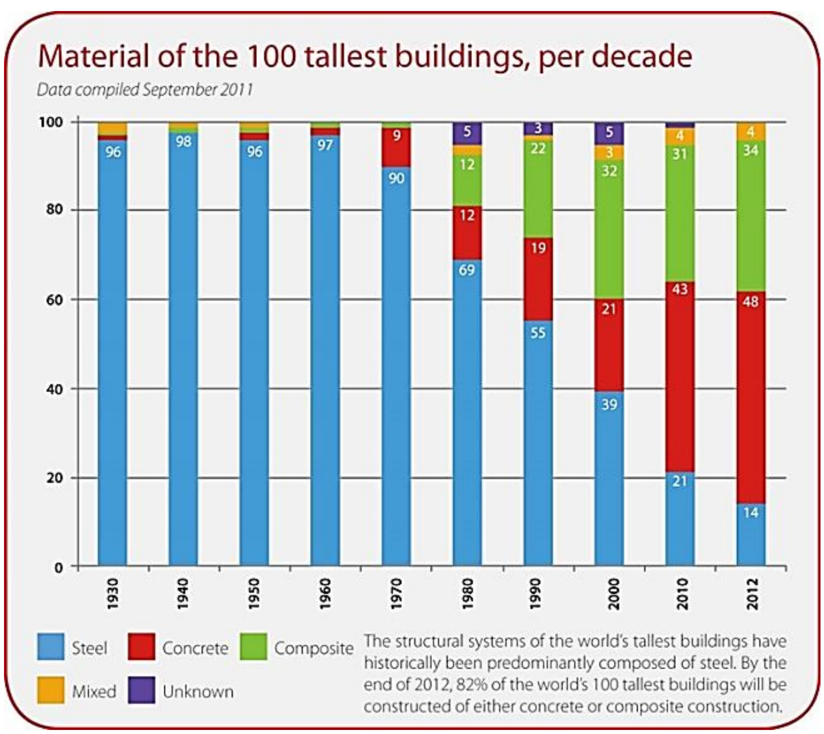

Figure 16: Changes in structural materials of tall buildings in the last decades

V. Possession of the Technical Knowledge

Historically, it is difficult to separate the development of tall buildings from technology, whether in their construction or usage. Perhaps this is one of the reasons that restricted tall buildings spatially in relation to the grounds of their technology. But in spite of the liberation of tall buildings from this chain many decades ago and their spread everywhere around the world, the concept of the world's tallest building was still bound by that original chain, which was not broken till 1998 by the Petronas Tower in Kuala Lumpur. In the theme of the world's tallest building, there is still concern about technical knowledge. In the case of Burj Khalifa, is technical knowledge a potential in its emergence or could it have been counterproductive? According to the determinants of place, if we assume theoretically that Dubai has succeeded in embracing the event of Burj Khalifa, this means Dubai has arrived at adulthood in technical knowledge without passing through childhood. According to Simondon, it is important to note that technical knowledge is truly rigid, and a community cannot become a child once again in order to acquire new basic intuitions.[131] Accordingly, anything that comes from the outside will be closed to the community unless they find a way to open it up. From this point of view, Dubai has offered a kind of openness toward technical knowledge of tall buildings through transferring it to a local knowledge or, specifically, making the technology (instrumental meaning) of tall buildings in all aspects a local industry. The meaning of the local industry or local technology here takes on the common meaning of traditional, which is related to the ability to use something in its place. On the other hand, in tall buildings, there is the global meaning of their technology, which explains the wide spread of the tallest buildings in the Middle East in spite of these countries' not having had the technology previously. Of course, the meaning of the appropriate technology in relation to a specific tallest building is diverse and variable as per the place and time and what is appropriate for one building rather than another. In this light, could technical knowledge be a potential in the emergence of the tallest building in the Middle East and specifically in Dubai? Concerning the technical knowledge for constructing tallest buildings in the reality of Dubai two facts arise that make Dubai cross the threshold of technical knowledge from childhood to adulthood. As I

[131] Simondon, *On the Mode of Existence of Technical Objects,* 15- 16.

explained earlier,[132] Dubai has taken tall buildings as an approach for development, which can be recognized obviously through the number of tall buildings in comparison to the size of the city. In Dubai, according to CTBUH, there are more than 230 buildings over 100 meters in height; 20 of them are supertall and one megatall.[133] In addition, Dubai began its experience with tallest buildings in 1994 when it constructed Burj Al-Arab and then the Emirates Towers two years later, which are still on the list of the 100 tallest buildings in the world[134] (Figures 17-18). This made Dubai into the most attractive destination for the companies and individuals who are specialists in the design and construction of tall buildings. In less than one decade, Dubai qualified as a world center of tall building technologies. Simultaneously, gathering companies and specialists in Dubai has contributed dynamically to the founding of what looks like a network for those engaged in this type of building and has created links between the branches in Dubai and their main offices around the world. It is a kind of magical world in which, as for Simondon, there is "a network of places and things that have a power and are bound to other things and other places that also have a power."[135]

Also, Simondon determines another level of understanding the technical knowledge through the meaning of technicity, whereby he argues that transferring technicity is confined to the level of elements only.[136] For this reason, according to Simondon, there is no fundamental difference between peoples who have no industry and those who have a well-developed industry.[137] He adds that even among peoples with no industrial development there are technical individuals and technical ensembles.[138] Therefore, instead of being stabilized by the institutions that establish and perpetuate them by installing them, these individuals and ensembles are temporary or even occasional; what are

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[132] Refer to 'Real Estate as Approach for Development' in chapter two.

[133] CTBUH, *All Tall buildings*.

[134] CTBUH, *100 Tallest completed buildings in the world.*

[135] Simondon, *On the Mode of Existence of Technical Objects,* 63.

[136] Ibid.

[137] Ibid., 66

[138] Ibid.

Figure 17: Burj Al-Arab is ranked 51st among the tallest buildings in the world

Figure 18: Emirates Towers is ranked 30th among the tallest buildings in the world

retained from one technical operation to another are the elements.[139] This point is related to understanding the role of elements in the technical object, which moves us to discuss Burj Khalifa as a technical object.

In short, understanding Burj Khalifa a technical object cannot be separated from realizing the potentials of its milieu, which manifest themselves in two different directions: horizontal and vertical. Horizontally, it is a moving of potentials centrically towards one place—Dubai. It is a concentration of the energy in what Simondon calls a privileged place, which carries the seed for the emergence of Burj Khalifa. On the other hand, there is a vertical direction, which appears as technical potentials often pushing Burj Khalifa to the maximum height. Similar to the crystallization of super-cooled water to ice, there is a particle that could be the stimulator of the system, which is filled with potentials, to catalyze and begin the appearance of the first concept of Burj Khalifa. Nevertheless, it is important here to distinguish between finding Burj Khalifa as a tall building and its concretization as a world's tallest building. In both, the potentials could appear as a stimulator to the milieu to cause Burj Khalifa to emerge as an ordinary building. But its evolution as a technical object required a different level of concretization as a technical object, which is the subject of the next part.

[139] Ibid.

The Theme of the Technical Object

Understanding a technical object as a regime can be a guide in order to determine the knowledge frame for realizing the meaning and value of the technical object in Burj Khalifa. At first glance, the relation between a technical object and any buildings seems ambiguous or complicated, especially when we look to the fields that technical objects are discussed in, as in the philosophy of Simondon. I see the key to this issue as lying in understanding the purpose. In other words, the aim of a building can be a key to understating the frame of the technical object. In fact, this orientation of discussing a technical object can be seen obviously in Simondon's approach whereby ends determine the value of the technical object. For instance, when he discusses the technical object in the wheel, the turbine and the locomotive, he focuses on the specific ends in each example and ignores the others, which essentially are part of the their characters. In the wheel, for example, the capacity, durability, and speed, which are part of its performance, are ignored in arguing for the scheme of the technical object. Ignoring them does not mean that they do not exist, but that they are implicated under the main purpose, or are hidden behind the main purpose, which determines the value of the technical object in itself. This approach to understating the technical object gives us the key to understanding the technical object in Burj Khalifa. Thus, the technical object as a regime is linked with the ends that determine its boundaries and its level. Looking to Burj Khalifa as a technical object from this angle manifests the value of height as an end in the emergence of the world's tallest building. And the other aspects that determine its being as a building, which are folded mostly under the Vitruvius triple schema, work together to synergize the whole system towards achieving that aim. Therefore, what is required from Burj Khalifa as architecture existed within its main direction as the world's tallest building. Burj Khalifa as a technical object is defined through its value as the world's tallest building, and any attempt to discuss any value or function away from this end (the height) is inaccurate and empties the event of its value. In like manner, a statement that "what was achieved in Burj Khalifa could be done in a low-rise building" seems incorrect because we have lost the value of the world's tallest building, which is of the essence in this subject.

Burj Khalifa as an Ensemble Technical Object

Arguing for the technical object in Burj Khalifa confronts us with a methodological question about the level of concretization of the technical object in Burj Khalifa. As I explained in chapter one,[140] Simondon has distinguished three types of technical object: an element, an individual and an ensemble; and each type has the characters that distinguish it from the others. Accordingly, Burj Khalifa cannot be identified as technical elements or individuals since implementing the ideas of technical elements does not fit in here because they pertain to primitive objects. I do not mean that there are no technical elements in Burj Khalifa. On the contrary, there are many of them, such as walls, arches and doors, all of which can be technical objects. On the individual level, the associated milieu appears as obligatory. According to Simondon, we can identify a technical individual when the associated milieu exists as a sine qua non condition of its functioning.[141] On the other hand, at the ensemble level, the associated milieu is either not a part of defining a technical ensemble or it is undesirable. As well, a technical ensemble is a system that involves sub-ensembles or individuals whose operational principle arises from different scientific domains.[142] Functionally, for Simondon, "[the] technical ensemble is itself made up of a number of technical individuals that are arranged in terms of the result of their functioning and in such a way that they do not interfere with the conditioning of their particular functioning."[143] Also, he adds "the principle of the individualization of technical objects in an ensemble is therefore that of sub-assemblies of recurrent causality in the associated milieu; all the technical objects with a recurrent causality in their associated milieu should be separated from one another and should be connected in a way that preserves the mutual independence of their associated milieus."[144] Defining Burj Khalifa as ensemble helps us to understand the redistribution of functions, which are brought into the network of different systems, in abstract as much as in concrete objects. Not only these reasons but also the complexity of Burj Khalifa makes us think precisely about defining it as a technical

[140] Refer to 'Levels of the Technical Object' in chapter one.

[141] Ibid., 53.

[142] Ibid., 4.

[143] Ibid., 57.

[144] Ibid., 55.

ensemble in which the essence of its concretization as a technical object is the organization of functional sub-assemblies or individuals in the total functioning. In other words, defining Burj Khalifa as a technical object at the ensemble level directs us to realizing the system as a combination of diverse parts which work firstly as technical individuals to achieve their specific role and, simultaneously, synergize each other to achieve the main purpose of the whole system. This imagining of the different roles of the parts within the ensemble leads to seeing the ensemble of Burj Khalifa as a group of sub-ensembles and individuals, such as the structural system, the architectural system and the services systems, where each system has two roles: supporting its existence and supporting the existence of the whole system. In the midst of this distribution of roles of Burj Khalifa's systems, are all the parts or systems equally important? Although, in the end, the building is a result of the synergies of all the systems together under one aim, it seems the importance of the systems varies depending on their role in the main direction, which in our case is the issue of the world's tallest building. Actually, we have to consider initially that the importance of each system is diverse, for we cannot look at the structural issue in same the way that we look at the interior or the landscape. Of course, the failure of the drainage system, which may assume less importance than the structure, in Burj Khalifa could cause the whole system to fail, but we still have to keep in mind that there is a main direction of concretization in Burj Khalifa as the technical object of the tallest building ever.

Concretization of the World's Tallest Building as a Technical Object

The height of Burj Khalifa as the tallest building in world, or specifically the tallest man-made construction ever, reveals itself as a main problem in its design. As shown in Figures 19 - 20, Burj Khalifa is a composite of 162 floors and it soars to 828 meters (2,717 feet). Undoubtedly, as I explained earlier, the technical object in Burj Khalifa lies in the schema of concretization that evokes its invention as the world's tallest building. The technical object, essentially, is crystalized as an abstract paradigm in the mentality of the designer or engineer as the inventor of the system who observes it emerging as an existing entity. For Simondon, the "technical object is not a physical natural system; it is the

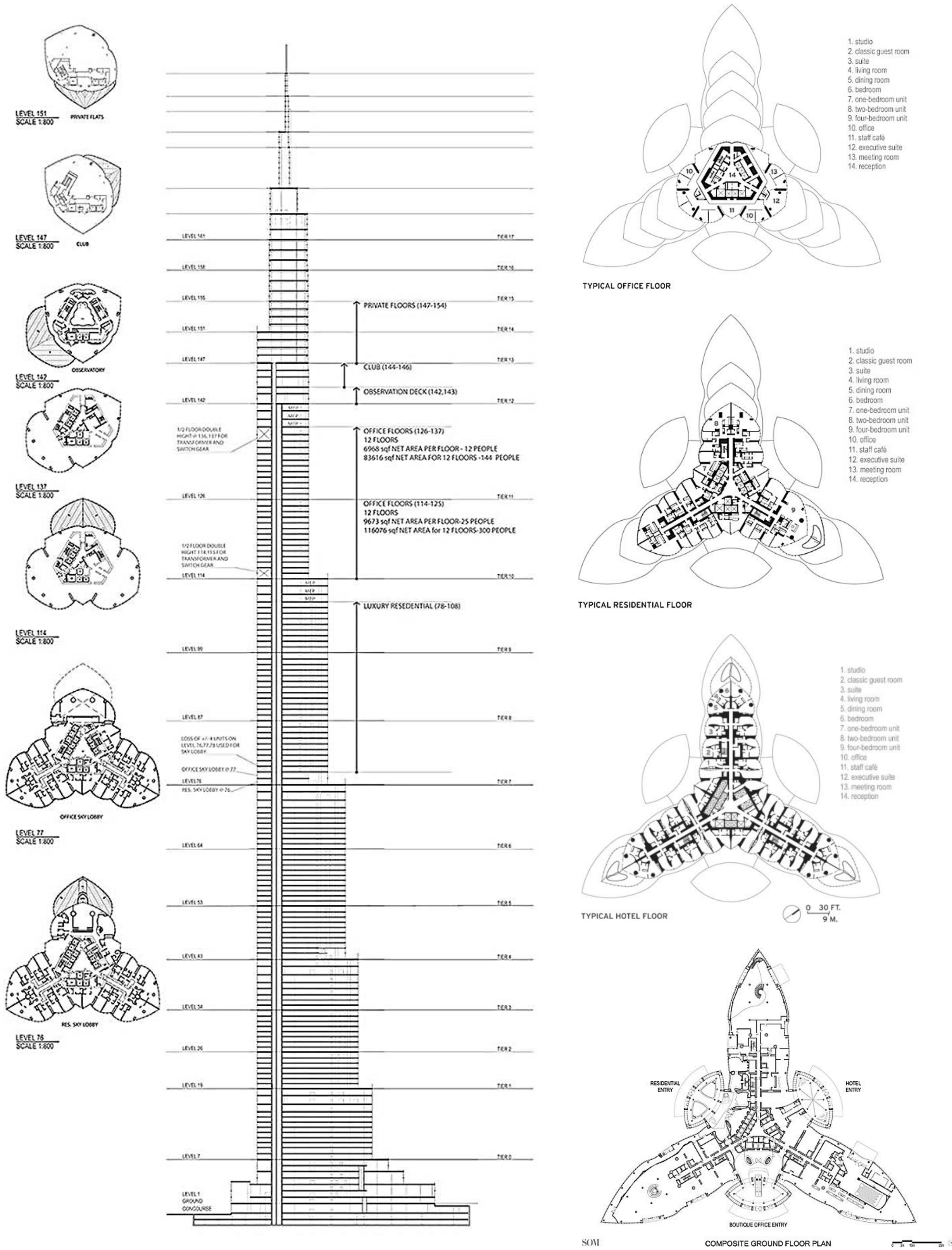


Figure 19: Burj Khalifa - Architectural Layouts

a.

b.

Figure 20: Site Plan and Aerial View of Burj Khalifa

physical translation of an intellectual system."[145] Its origin is purely cognitive and entirely internal to the human thinking subject.[146] Accordingly, as I explained in chapter one, for Massumi, "human thought precognizes a solution then externalizes it by finding a way to mould matter to the form of its pre-thought solution."[147] Thus, "The practical finding of that way would be the technical process: the set of mediating actions shepherding the abstractly thought object into concrete embodiment."[148]

In the design of tall buildings, the structure of the building often opens up a wide space for debate, which belongs essentially to defining a building as a tall building. Principally, structure provides a stability of building, which is represented as a standing against extrinsic influences such as wind and earthquake, which are defined technically by wind and seismic loads. As well, it should be able to resist the intrinsic loads such as the loads of its elements, occupants and equipment or what are called dead and live loads. The effect of each of these loads is various according to the location and nature of the project. Through meteorological data of the location of Burj Khalifa and its extraordinary height, the winds appear to be the major issue for its existing. In the structural design of tall buildings, the structural elements are designed to transfer the lateral load of the wind through the structural elements to the ground. The efficiency of this transformation of load depends on the strength of the elements, which is determined mostly through their materials and sizes, and the connections among them. In the case of Burj Khalifa, the nature of the winds at high altitudes makes depending on the capacity of elements, or their strength, to resist the wind load impossible since the required size of structural elements would exceed rational limits. Besides, increasing the materials and sections of the structural elements affects negatively the spaces, especially on the upper floors, and the accumulated loads of the system generally. The relation between traditional solutions for the design of structural elements and the results does not suggest any margin to achieve the exceptional height of Burj Khalifa. It was a dead end and there was no chance of getting beyond it.

[145] Ibid., 40.
[146] Arne De Boever, 24.
[147] Ibid., 24.
[148] Ibid.

Through reviewing the models that preceded Burj Khalifa, dealing with the structure of the world's tallest building was achieved by providing the required capacity of the elements to resist the different loads caused by the exceptional height. Historically, the tube system, which was invented by Fazlur R. Khan in the 1970s, was known as a dramatic shift away from the traditional portal frame system used in structures such as the Empire State Building.[149] Later, the gradual development of the tube system by using the core plus the outrigger system added some efficacy to the structural performance and led to an increase in the ability to go higher.[150] But, still, as I said before, the change in height was limited from one step to the next. Officially, the last stage of the structural development was in Tower Palace III, located in Seoul, designed by Chicago-based Skidmore, Owings & Merrill LLP (SOM) and completed in 2004, but its height does not exceed 264 meters, 73 floors[151] (Figure 21). Innovation of the buttressed core in Burj Khalifa, which included two elements, the central core and tripod-shaped wings, represents a new approach to dealing with structural issues and permits a spectacular increase in height. According to William Baker—structural engineer of Burj Khalifa— "the essence of the system is a tripod-shaped structure in which a strong central core anchors three building wings."[152] The multifunctionality of the structural elements, which are arranged in a Y shape, makes the whole system inherently stable; each wing buttresses the other two through the connection of the central core and provides shear resistance and increased moment of inertia.[153] Further, the Y shape has low aerodynamic or hydrodynamic drag, or what is known as drag coefficient, whereas the surface areas of each side of the Y wings make the building's resistance to the lateral wind load similar to that of a cone shape[154] (Figures 22-23). On the other hand, the central core's being the hub of the services of Burj Khalifa, such as elevators

[149] William F. Baker and James J. Pawlikowski, "Higher and Higher: The Evolution of the Buttressed Core," *Civil Engineering-ASCE* (October 2012): 59.

[150] Ibid.

[151] Ibid. and Wikipedia, "Samsung Tower Palace 3 – Tower G," *Wikipedia, The Free Encyclopedia*, March 12, 2014. http://en.wikipedia.org/wiki/Samsung_Tower_Palace_3_%E2%80%93_Tower_G (Accessed July 12, 2014).

[152] Baker and Pawlikowski, 59.

[153] Ibid.

[154] Wikipedia, "Drag coefficient," *Wikipedia, The Free Encyclopedia*, June 18, 2014. http://en.wikipedia.org/wiki/Drag_coefficient (Accessed July 12, 2014).

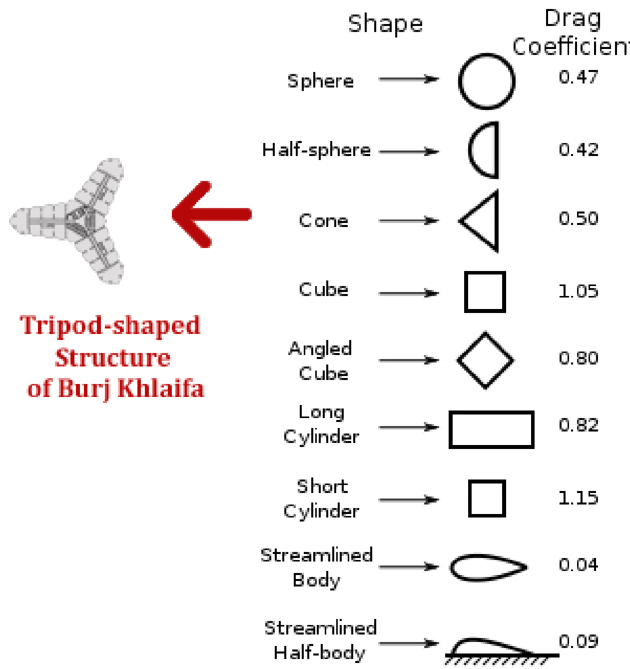


Figure 21: Tower Palace III

Figure 22: Drag coefficient of different shapes

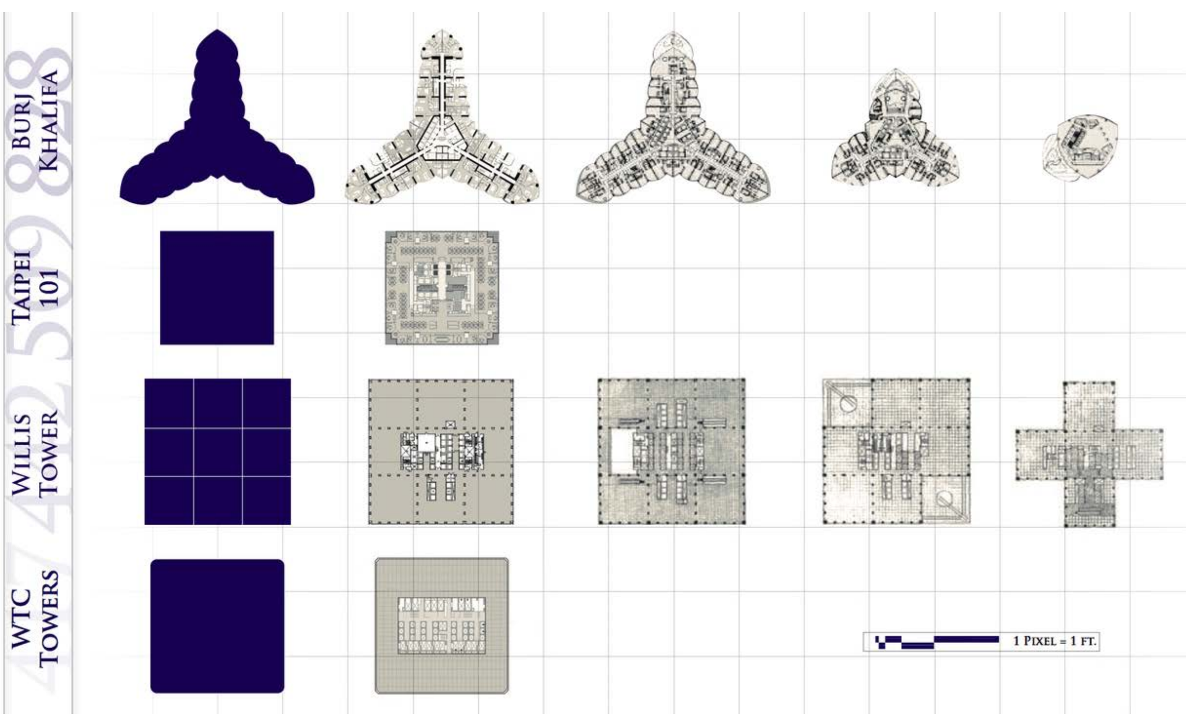


Figure 23: Comparison between Burj Khalifa's shape and other supertall buildings

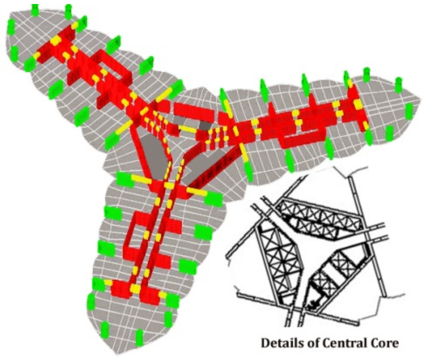
and network shafts, makes it like a huge central column supporting the heart of the building (Figure 24). Functionally, the central core, or the hexagonal hub, is a multifunctional element. Through its acting as a torsional resistance, the central core works like an axle to resist the twisting of the tower while it supports the wings at the same time.[155] Its role as a torsional resistance reflects positively on the arrangement of the structural walls and perimeter columns, the secondary structural systems in building. It helps to increase the ability to open through the structural elements (structural walls) and eliminate the perimeter columns by using cantilever beams from the core walls.[156] Vertically, there are twenty-six setbacks in the buttressed core system, which decrease incrementally as the building swirls skyward and sculpt the overall shape of the structure giving it a tapered profile—slender at the top and wider at the base (Figure 25). This logical tapered shape is a causality resonance of the direct relation between cause and effect where the shear and bending moment accumulate from the top to the bottom. This kind of shape is rational when bearing in mind the whole structure as a cantilever beam fixed in the ground (Figures 26-27).

In ordinary tall buildings, the initial perception of the structure shows large movement, which makes the tower behave as pendulum against the sky. But in Burj Khalifa, the structural elements—buttressed core and setbacks, which represent different elements—come together in a new situation creating a new regime, which makes the structural system become stable as the world's tallest building. The birth of the new regime is an invention of the technical object. For Simondon:

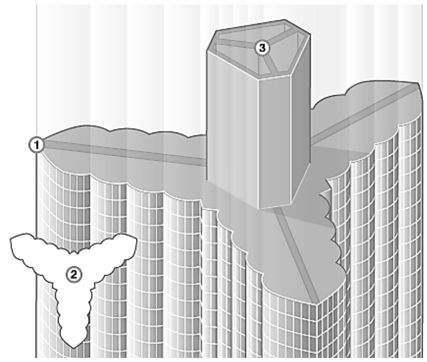
> The technical object stands at the point where two [milieus] come together, and it ought to be integrated into both these [milieus] at the same time. Still, these two [milieus] are two worlds that do not belong to the same system and are not necessarily completely compatible with each other. Hence, the technical object is delimited to a certain

[155] William F. Baker, "The Burj Khalifa Triumphs: Engineering an Idea: The Realization of the Burj Khalifa," *Civil Engineering-ASCE* (March 2010): 47.

[156] Baker and Pawlikowski, 60.



a.



b.

c.

d.

e.

Figure 24: Buttressed core structural system of Burj Khalifa

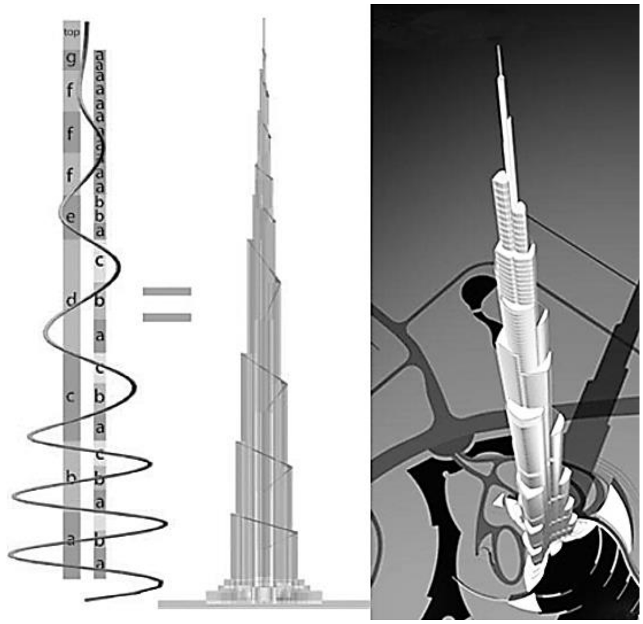


Figure 25: Setback spaces in Burj Khalifa

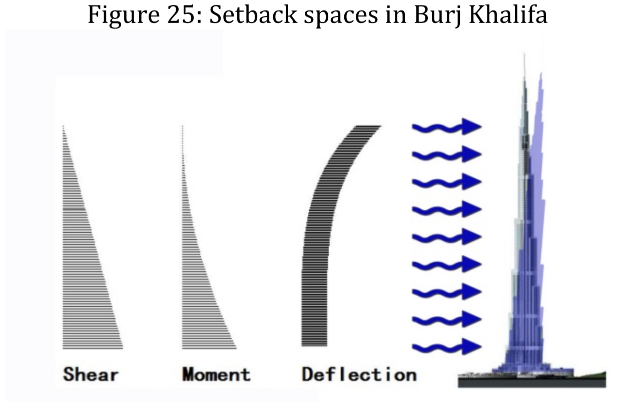


Figure 26: Relation between Burj Khalifa's shape and the structural facts

Predicted Wind Drift based on 50 year wind event

Location	Drift (mm)
Top Commercial	1450
Top Office	1250
Observatory Area	750
Top Residential	540

Figure 27: Predicted wind drift based on 50-year wind event

> extent by human choice which tries to establish the best compromise possible between these two worlds.[157]

Structurally, in Burj Khalifa, there are different elements (buttressed core and setbacks) and each one has a specific ordinary role, but when the associated milieu or regime is concretized they behave in an unexpected way. A careful examination of the performance of the structural system shows that the structural issue is shifted from the capacity of the elements to the geometry and its orientation, which offers potential energy to manipulate the dynamic properties in order to minimize the harmonics of the wind forces.[158] The new regime, which results from the buttressed core and setbacks, makes the structural system as tunable as a musical instrument. The setbacks control the tone of the winds' parameters by creating different tones of the winds (three types of winds) that are distributed vertically throughout the building (Figure 28). Moreover, the tapered shape of the buttressed core, which results from changing the dimension of the floors vertically, contributes to adding new factors for the confusion of the winds, especially in relation to their speeds (Figure 29). Therefore, the vortex shedding occurs at different rates on different portions of the tower for the same wind speed.[159]

The orientation of the tower and the direction of its setbacks relative to the most frequent directions of wind in Dubai, which are northwest, south, and east, show substantial reduction in the effect of wind forces and the impact of winds' tails on the building[160] (Figure 30).By confusing the winds, the structure disorganizes vortex shedding over the height of the tower and the effect of winds on the world's tallest building becomes similar to their effect on a normal tall building. Truly, the situation is extraordinary because of the way in which the building behaves as if it were groups of different buildings set over each other; the accumulation of non-homogeneous shapes of buildings produces what

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[157] Simondon, *On the Mode of Existence of Technical Objects,* 46.

[158] Baker and Pawlikowski, 59.

[159] Richard Tomasetti, joseph Burns and Dennis Poon, "The Limits of Materials and Structures," in *The Tall Buildings: Reference Book*, ed. Dave Parker and Antony Wood (London: Routledge, 2013), 202.

[160] Baker and Pawlikowski, 62.

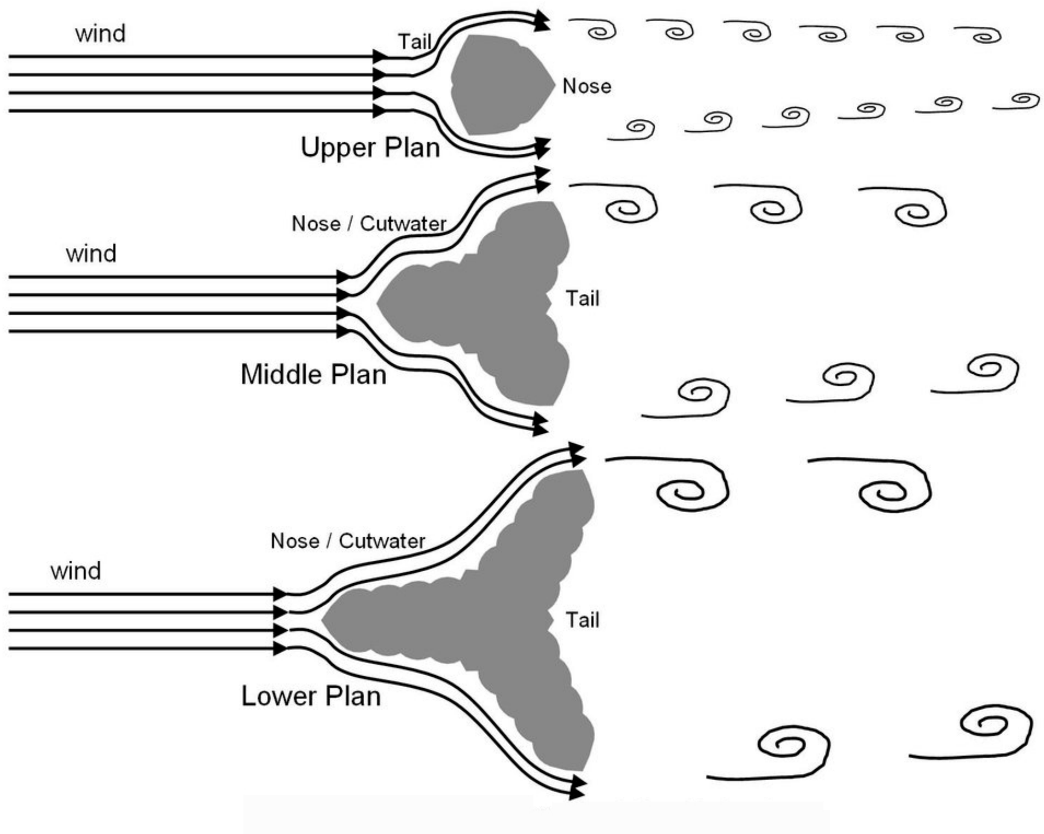


Figure 28: Confusing winds and disorganized vortex shaping behavior

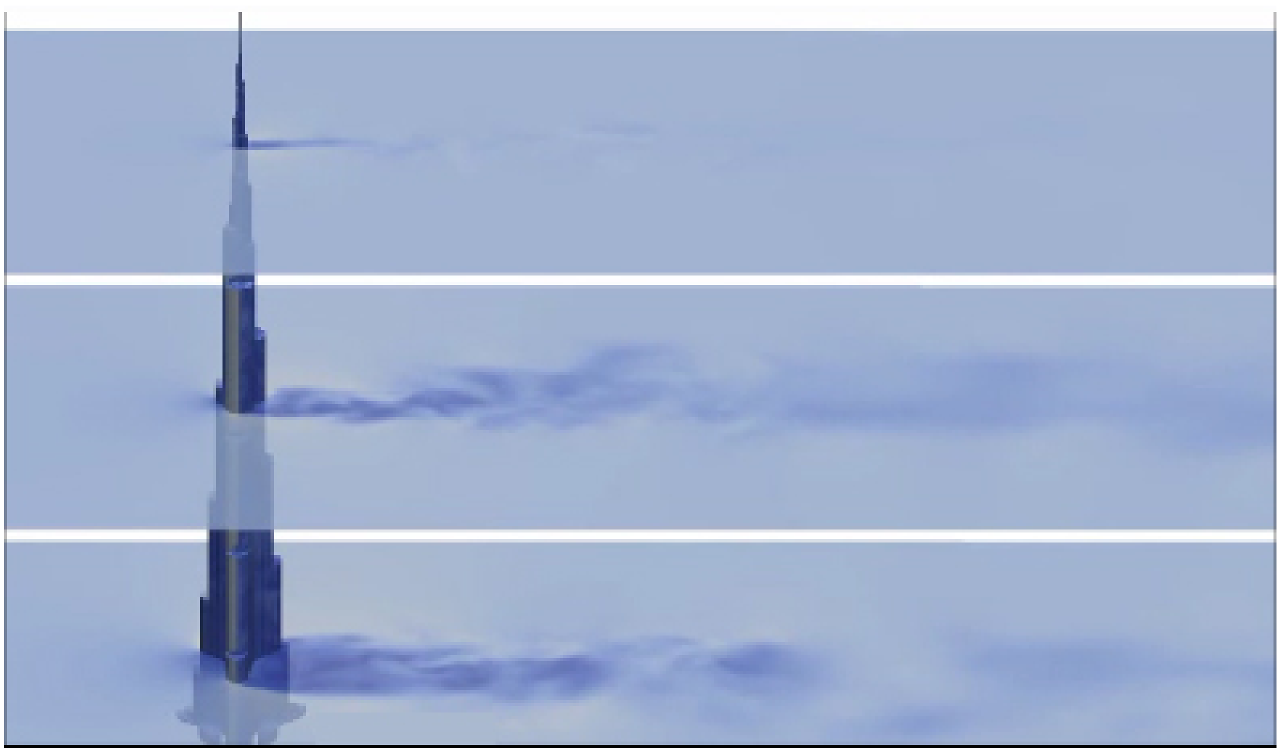


Figure 29: The differences of speeds of winds along the whole length of Burj Khalifa

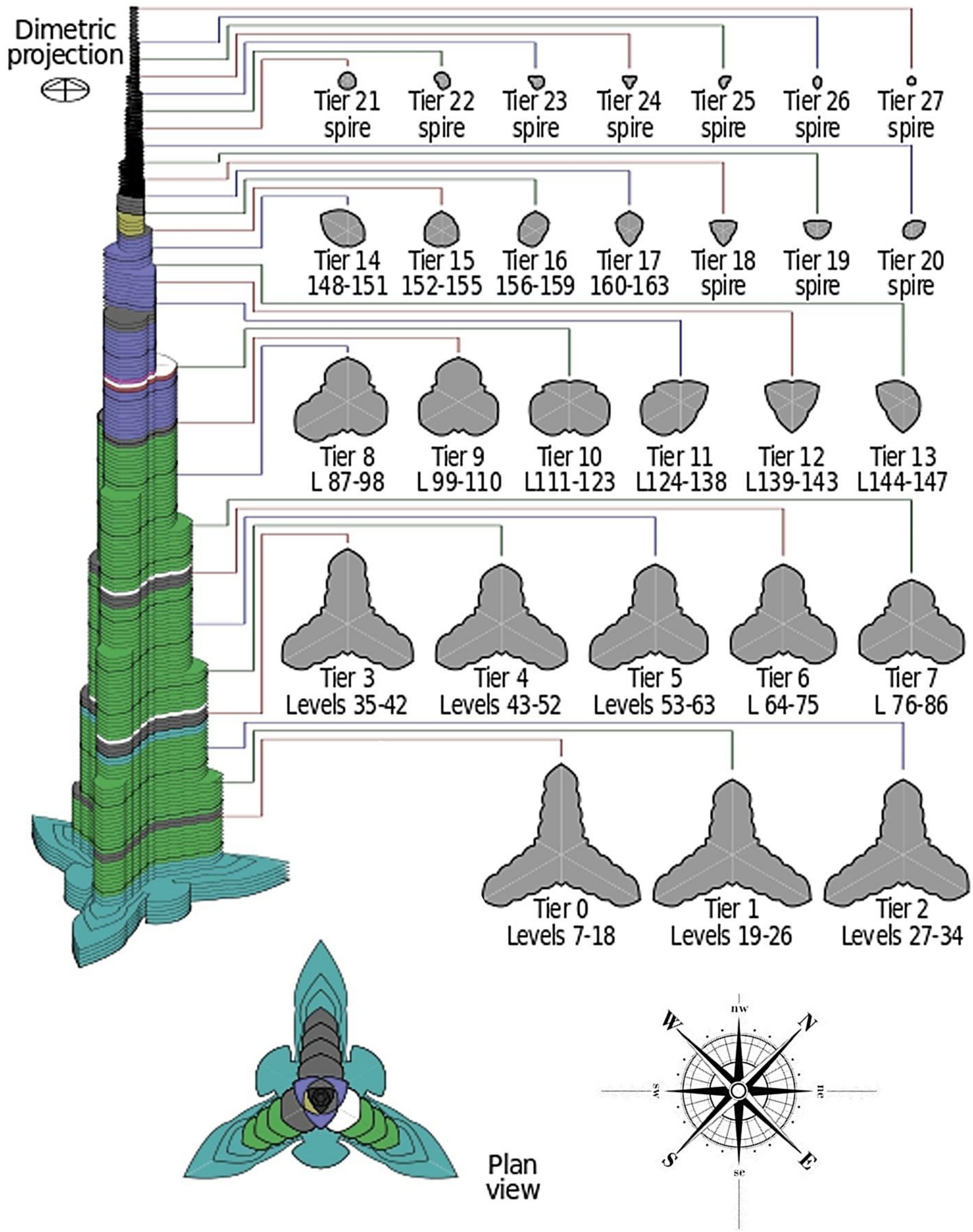


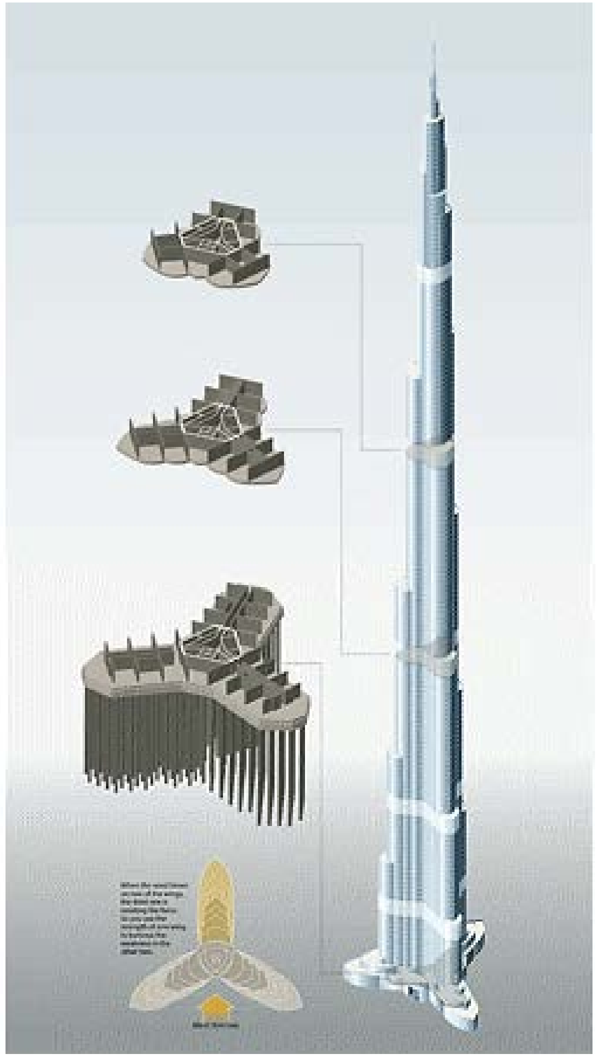
Figure 30: The changes in tiers and the directions of the setbacks in Burj Khalifa

looks like a different pattern that confuses of the winds. Each one opposes the other so that the sum total equals nil.

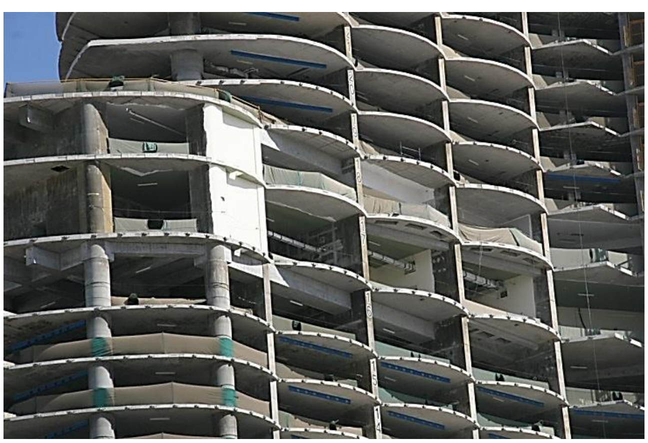
In the same context, the buttressed core is connected with other elements: the perimeter columns and the outrigger walls. Structurally, the perimeter columns are enhanced structural elements which increase the structural performance through engaging the perimeter for lateral load resistance. While the outrigger walls, which are found in the setback floors—the mechanical floors—allow redistribution of the loads resulting from the floors located above them several times throughout the building's height[161] (Figure 31). Arraying the outrigger walls five times through the total height ties the vertical structure in order to maximize the stiffness and stability of the building.[162] These two supporting elements (perimeter columns and outrigger walls) enhance the performance of the main structure—the buttressed core—through controlling any differential shortening in the whole system and would be major improvements that increase in an essential way the synergy of functioning. The total behavior of the whole structural system (the main system and the augmentation system) has an absolute effect on the character of the elements; in contrast to many supertall buildings in which the columns on the ground floor are huge, Burj Khalifa's base columns are remarkably thin; and if they are compared to the top columns, they are only slightly thicker.[163]

The other multifunction of the structural system is its resistance to the gravity and seismic loads. For the gravity loads, managing gravity in the entirety of the structural elements can be the key whereby the loads move smoothly from top to bottom through simplified load paths avoiding transfer elements. As I clarified earlier, the role of the outrigger walls appears here like bundles of belts that tie together all the structural elements at the various heights. Additionally, the buttressed core and the 162 floors are organized as a tree in which the floor slabs behave as cantilever floors branching out from the central core despite there being columns to support them. This approach helps assure

[161] Ibid., 62.
[162] Tomasetti, Burns and Poon, 465.
[163] Baker and Pawlikowski, 62.



a.



b.

c.

Figure 31: Outrigger walls in mechanical floor

gravity stability at the top and bottom and decreases the effect of the dead load of the floors on the columns' size on the lower floors.

As for the seismic loads, Dubai is situated towards the eastern edge of the geologically stable Arabian Plate and is separated from the unstable Iranian Fold Belt to the north by the Arabian Gulf.[164] The site is therefore considered to be located within a seismically active area. The structure sits on a large reinforced concrete raft about 3.7 meters thick.[165] This raft is supported by 194 reinforced concrete piles with a 1.5 meter diameter, which are buried in the ground at 50 meters depth.[166] Because of the high water table and the effect of detrimental effects from corrosive chemicals in the local ground water, the foundations, both the raft mat and the piles, are made from high density, low permeability concrete; there is also a cathodic protection system under the raft.

Simply, the individualization of the structural system as a technical object aims to reach the maximum height of the tallest buildings with the available technology and materials and to avoid the problem of loads by ingeniously solving it. We have to remember that we are looking for sub-ensembles within whole ensemble. The key to understanding this process lies in linking the invention of the technical object to an action of the system in the future through an abstract paradigm in the present. At the moment when the structural elements synergize and circular causality pushes strongly, the real meaning of the invention emerges and the technical object is concretized.

Initially, the structural system has its main function, which is represented in carrying and transferring the loads. In normal cases, this causality would make achieving the target, the world's tallest building, impossible since the singular function of each element shows a shortcoming in its performance. In contrast to this, the evolution of the structure in Burj Khalifa is not a compromise but a concomitance and a convergence in which the elements synergize each other to concretize the technical object. The

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[164] Harry G. Poulos, Grahame Bunce, "*Foundation Design for the Burj Dubai—The World Tallest Building*," 6th International Conference on Case Histories Geotechnical Engineering (Virginia, August 11-16, 2008), 1.

[165] William F. Baker, Stanton Korista and Lawrence C. Novak, "Burj Dubai: Engineering the World's Tallest Building," *The Structural Design of Tall and Special Buildings* (November 2007): 365.

[166] Ibid.

multifunctionality is the character of the structural elements in Burj Khalifa. For example, as I described, despite the existence of the parameter columns, which, normally, can reduce the massiveness of the central core, the central core carries the main load of the floors slabs in order to enhance the whole system against the gravity loads. In this light, for Simondon, "the technical problem has to do with the convergence of structures into a structural unity rather than with the seeking of compromises between conflicting requirements."[167] Further, he adds, this divergence of functional aims remains as a residue of abstraction in the technical object, and the progressive reduction of this margin between functions of polyvalent structures is what defines the progress of a technical object.[168] The evolution of the technical object of the structure shows stages that are defined by the fact that they bring into being successive systems of coherence.

The potentials of the central hexagonal core, tripod-shaped wings and the setbacks create an ability for them to play multiple roles. The role of the central core in tall buildings is to gather vertical services such as elevators and networks within one specific space continuous over the entire height of the building. Structurally, its role is confined to resisting the lateral loads from the wind and gravity loads resulting from its weight and the elements connected with it. In Burj Khalifa, the central core's role takes a different direction; it becomes the main part to resist the torsional loads which originally result from the effect of the wind loads on the tripod-shaped form. In other words, the central core frees the tripod-shaped wings from the torsional loads. On the other hand, the multifunctionality of the tripod-shaped wings is to support the central core and the main location for the functional activities of Burj Khalifa. In normal cases, floor slabs are supported by structural elements such as beams or columns; but in Burj Khalifa, their shape, which is similar to that of a triple-lobed flower, resists the lateral loads resulting from the winds and supports the central core against the shear loads. The multifunctionality of the two elements—the central core and the triple shape—is enhanced by a third element—the setbacks, which are distributed spirally around the building and confuse the winds blowing around it. In like manner, the buttressed core itself has another

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[167] Simondon, *On the Mode of Existence of Technical Objects,* 21.
[168] Ibid., 21.

role to resist the gravity and seismic loads, which, generally, depends on the logical methods to carry the loads from top to bottom. Eventually, there are three sets of multifunctional potentials: the central core and the tripod-shaped wings, which form the buttressed core, and the setbacks. The moment of invention is when the three sets of potentials click together, coupling into a single continuous system. A new regime of functioning has suddenly leapt into existence and created what looks like a reverse system for the confusing winds around the whole building by hitting and terminating the original winds, which are the initial generator of the confusion. At the moment of the invention, the reverse power has crossed the threshold, like a quantum leap to a qualitatively new plane of operation. In that moment, Burj Khalifa becomes self-maintaining. It has achieved a certain operational autonomy because the potentials in the three structural elements have interlinked in such a way as to generate a kind of energy along the whole length of the building to confuse the winds and, at the same time, regulate the transfer of other loads to the ground automatically, allowing the tallest building to stand up independently.

If we return to the moment that proceeds the moment when the structural system passes the threshold, there were two different fields: the buttressed core and the setbacks. The buttressed core with both its parts—central core and wings—is a physical structural element with specific physical features, such as reinforced concrete walls, columns and slabs. On the contrary, setbacks are places in the space where only physical boundaries determine its shape. The respective energetic fields of the buttressed core and the setbacks are in a state of what Simondon calls disparity. “When the synergy kicked in, the disparity rolled over into an emergent continuity.”[169] The buttressed core and the setbacks belong to different fields; there is no common factor that can gather them under one category. But there is something else which has crossed the threshold and leapt into existence, it is the concretization as a technical object of the structural system. Although there is differentiation in fields, they go in the same direction as the condensation of multiple functions in the same structure. There is a regime of functions that crosses the threshold to bring another paradigm of operation into existence. That paradigm of operation, which achieves the stability of the structure, continues despite the differences among the

[169] Arne De Boever, 25.

elements. In fact, the new regime separates itself to claim an operative autonomy as a qualitatively new regime of functioning.[170] It is a new value of the operation of the structural elements in which the multifunctions of the elements enter as potentials into concretizing the technical object. There is a recurrence of causality between the regime and the structures. The structure plays an informational role; it is the seat of self-regulation, the vehicle for information, while the regime is a theater for dynamic action.

The emergence of the regime of the structure in this uncommon way makes us question the resources of the invention. The multifunctions of the structural elements were not in effect before crossing the threshold, and the potentials of the structural elements were not affected in the past (before crossing the threshold). In fact, the influence of the potentials has been invented in the future. For Massumi, "Invention is the bringing into present operation of future functions that stimulates the present for an energetic leap into the new."[171] Accordingly, in the concretization the technical object, we are not looking to the past while we are looking to the future. Therefore, for Simondon, "A technical invention does not have a historical cause, it has an absolute origin: an autonomous taking-effect of a futurity, an effective coming into existence that conditions its own potential to be as it comes."[172] The result is a manifestation of a technical object standing independently and apart from the whole system—the ensemble of Burj Khalifa.

Synergies in the Technical Object

Before proceeding to argue for the idea of the synergy of the systems in Burj Khalifa, it is necessary here to determine the visualization about the roles of the system in the ensemble. As I explained earlier, Burj Khalifa represents an ensemble technical object, which means that many systems or elements are involved in its composition. Each system or element in Burj Khalifa is a nominee to be an individual technical object in itself, for instance, the elevator system or the envelope system. However, the role of these systems stems from being systems in the ensemble, and their appearance as synergies of the main

[170] Ibid.
[171] Ibid., 26.
[172] Ibid.

direction of the world's tallest building is what completes our visualization of Burj Khalifa as a technical ensemble.

The early explanation of the structure shows that its main direction is to achieve the ability of the system to rise stably 828 meters in height. The success of the whole system as a technical object is not achieved through the structural system, but only through the synergies of all the systems in Burj Khalifa. Each system can best complete its own function as a perfectly finalized instrument, while at the same time it is completely oriented towards the performance of the whole function. For instance, in addition to what we have seen in the form of the movement of buttressed core and tripod-shaped wings from potentials towards the main direction of the ensemble, there is another dimension of those potentials. Architecturally, the tripod-shaped form provides the panoramic view to the occupants, where the angle of the view reaches to 120 degrees (Figure 32). Moreover, the tripod shape integrates both the need for a view and privacy. The high level of privacy, which I will discuss also in dealing with the divisions between the units, is concretized here from the perspective of overlooking. The direction of each wing of Burj Khalifa prevents overlooking, which according to the Dubai regulations should be complete with zero tolerance.

A permanent exchange of information between any system and the whole ensemble appears as an imperfection if this exchange is not part of the whole theoretical functioning. In fact, the abstract form of each system is treated as an absolute that has an intrinsic perfection of its own and needs to be constituted in a closed system in order to function, for instance the elevator system. Simultaneously, its integration into the ensemble involves a series of problems that should be resolved. In fact, these problems are technical or issues of incompatibility from or between already established systems, as occurs, for instance, between the elevator system and the height of Burj Khalifa, where the limitations in the elevator system hinder the continued achievement in the height.

Burj Khalifa is similar to a vertical city, with different functions and about 4,000 tenants and visitors.[173] All those people have only one way to get out the building, namely,

[173] Fortune, 47.

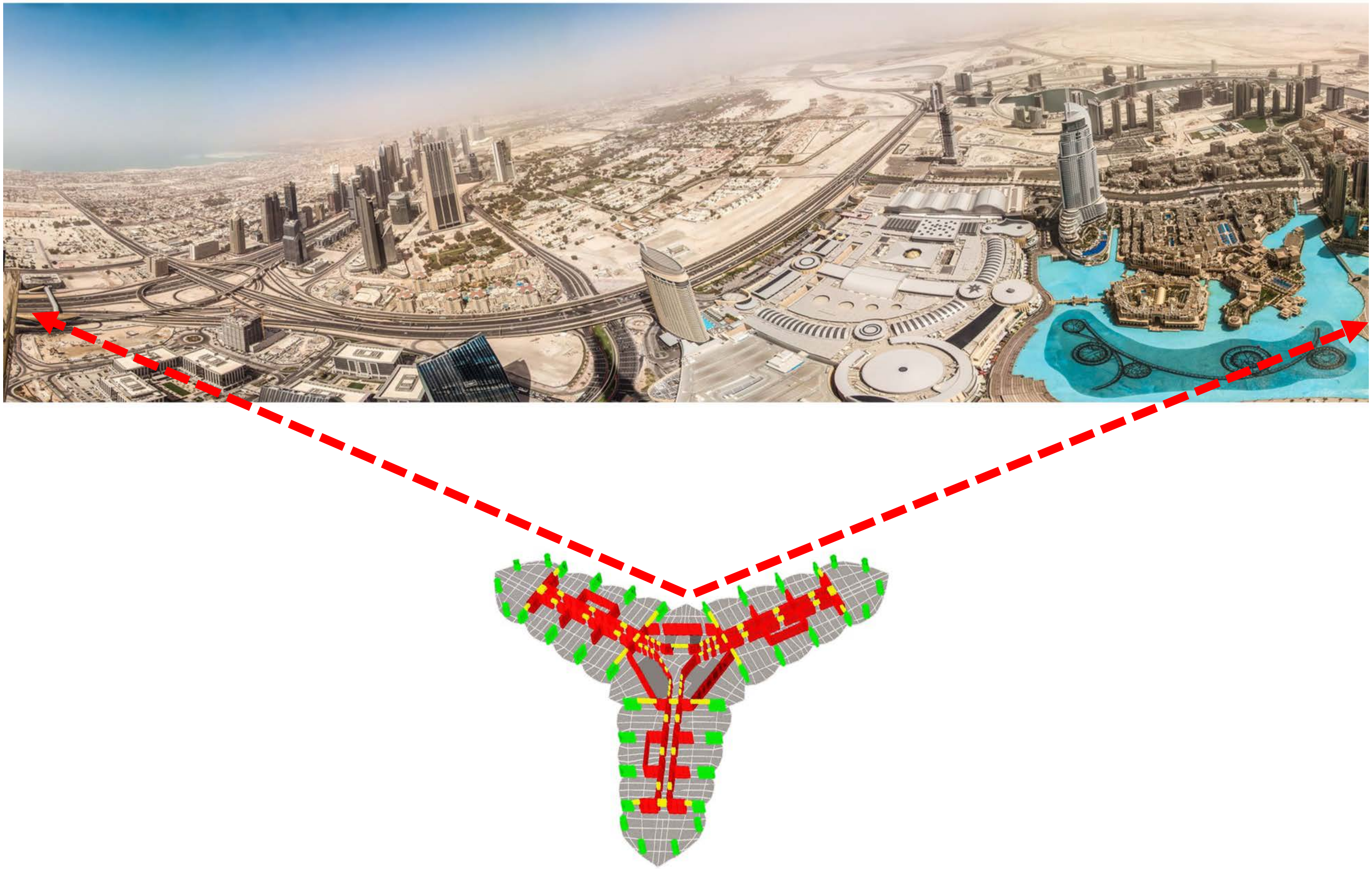

Figure 32: Panoramic view from a typical floor in Burj Khalifa

by going down to the ground floor via vertical transportation. Just imagine this huge number of people passing through a tube—the central core—to reach the front door. Really, it is a stumbling block for any building. From the angle of the synergy in the ensemble of Burj Khalifa, enhancing the main function of the ensemble seems the main direction of the elevator system, and smoothly transferring people through vertical transportation seems a specific function of the system. Accordingly, we have two levels of the function, one in the system itself, which is achieved through its elements as an individual technical system, and the other, which relates to the other systems to synergize the main function of Burj Khalifa. The whole building is served by 57 elevators (Figure 33). The function of the system depends on three main elements. The first is using the double level elevator shuttle (2 x 21 people on two cabin levels), which has become basic in supertall buildings.[174] Also, utilizing high speed (up to 700 meters per minute) non-stop shuttle elevators permits transferring people to a sky lobby.[175] Sky lobbies, which are the third element, are used as terminals linking the express and local elevators, which are similar to railway system lines in cities around the world.[176] Here, the different locations of the elevator stops along Burj Khalifa show a new level of the synergy between the structural and the elevator systems. Placing local elevators on the upper floors requires spaces for elevator pits, overruns and machine rooms for each group. And if we look at the section of Burj Khalifa, we can see the difficulties in providing these required areas because they conflict with the floors that are above and below the local elevators. Baker mentions in his comments on the development the ideas of the structural system that he requested to insert outriggers into the structural system to bundle the vertical structural elements. At that time he hoped to get a double floor height for the outriggers. Contrary to what was expected, the result was surprising; the synergies of all the systems in the ensemble provided a triple-height floor for the outriggers, which in addition to its structural benefit provided space for the elevator pits and overruns and machine rooms; it also added efficiency to the size of the water tanks that are located there. Actually, the synergies between the outriggers, the mechanical system, the elevator system and the sky lobbies

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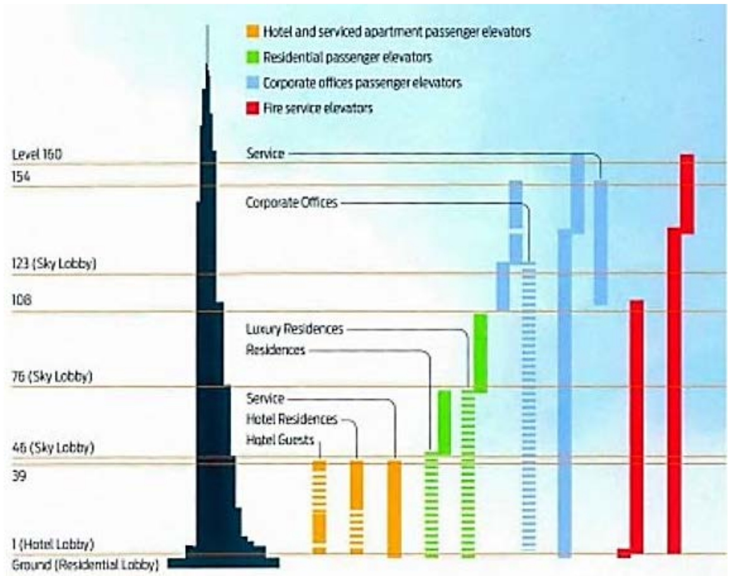
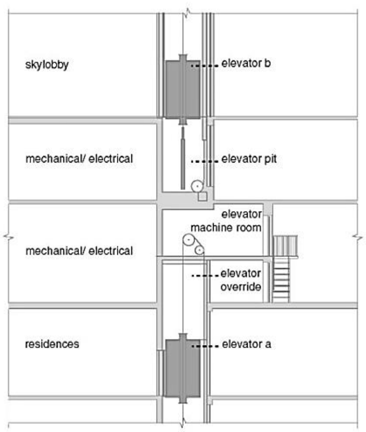
[174] Jakob Schoof , "Vertical City," *Plus Movement in Architecture*, Issue 1(2008): 17.

[175] Ibid.

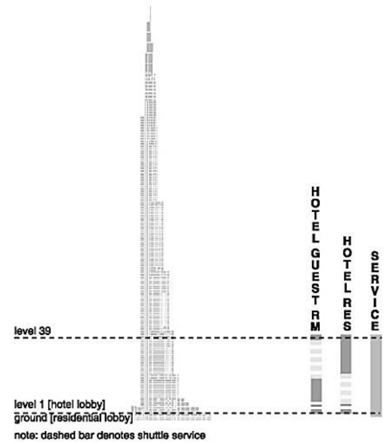
[176] Ibid.



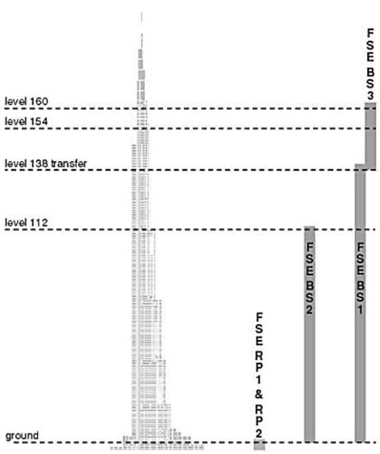
a. Matrix of the Burj Khalifa's elevators



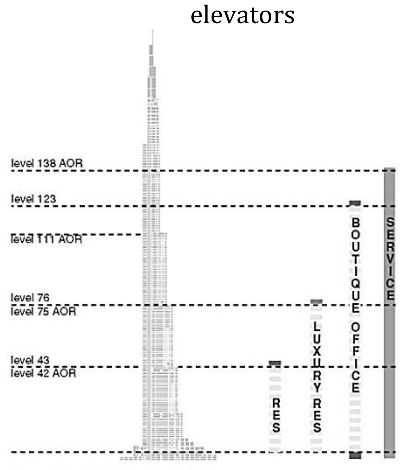
b. Details section showing the stacking of elevator groups at mechanical floor



c. Hotel and services apartment passenger elevators



d. Fire services elevators



e. Building section showing 'Lifeboat' emergence service elevator operation

Figure 33: Elevators system in Burj Khalifa

provided an optimum solution for the success of Burj Khalifa by opening up new dimensions to enhance the individual functions of the systems and the main functional direction of the whole ensemble. The elevators are grouped according to the function of the zone, which avoids an intersection between the different usages of the floors. The achievement was finding the longest elevator travel distance in the world (504 meters), the tallest service elevators in the world and a new innovative elevator system for fire and safety.

In supertall buildings, firefighting elevators seem a practical solution; but, as mentioned earlier, the tragic pictures of the events of September 11 and the horrific clips of people stuck on the upper floors made fire safety a crucial matter in the construction of tall buildings. As a result, the need to find a new level of safety seemed an urgent necessity for the success of the height of Burj Khalifa. The problem that confronted the project at that time was the exceptional height of Burj Khalifa, which created a major concern: there were no codes, norms or experience that could support any hypothesis to solve the safety issue for 162 floors. In fact, the potentials of the ensemble and the multifunctions of the elevator system provided a unique solution to this problem. The solution of the system depended on finding a mechanism to deal with fire and safety according to the level of an emergency, which is represented in two ways: normal and extraordinary emergency events. The mechanism in each case depends essentially on the synergy provided by the structural system, which provides a high fire-rated shaft through the thickness of the reinforced concrete walls of the central core. In a normal emergency, the service elevators, which serve all floors, work as firefighting elevators to provide access to each floor and can be used as fire escapes too. This solution confines the process within the main service elevators and avoids using the local elevators that move between the floors. In an extraordinary emergency situation, the new system leaps in and the high-speed shuttle elevators become lifeboats. In fact, a new elevator system appears here to support the main function of Burj Khalifa. Three different groups of elevators can be transformed into lifeboats: the three high-speed shuttles serving the Level 43 residential sky lobby, the three high-speed passenger shuttles serving the Level 76 residential sky lobby, the two very-high-speed double-decker passenger shuttles serving the Level 124 observatory and the

Level 123 corporate suite sky lobby, and the two building services/firefighting elevators, both serving up to Level 111 and one serving up to Level 138.[177] Each elevator in each group can be worked manually through the control terminal, which controls the stops, opening, speed, communications and the movement of cameras inside the shuttles.[178] This system is integrated with pressurised, air-conditioned refuge areas located at approximately every 25 floors, which are used as fire-rated rooms for both emergency levels.[179] As a result, the estimated time to fully evacuate the building using stairs and 'lifeboat' emergency service was reduced by 46% from that of using stairs alone.[180] If we resurvey the elevator system, we find that, as an individual system, it has succeeded in achieving its individual requirements, as well as its main functions as per the architectural and structural requirements. At the same time, it synergizes the direction of the main function of Burj Khalifa forward to achieve its goal as the world's tallest building.

Suppression as Synergy in the Technical Object

In the technical object, as was discussed earlier, the differentiation in the systems goes in the same direction as the condensation of the multiple functions of the systems. Reciprocal causalities among the systems in the ensemble allow a kind of suppression of secondary effects that were formerly obstacles. To explain this matter, in megatall buildings, the factor of occupation in the upper floors is an obstacle against continuing to go up for many reasons: increasing the accumulation factor of people, which reflects directly proportionally on the number of elevators, the fire safety requirements, the economic factor (the feasibility) and, finally, the comfort factor (the rocking percentage of the building). Each factor shares directly or indirectly in many other systems, which means more obstacles against the ensemble of the building. As I explained concerning the potentials of the new approach of designing tallest buildings, there is a new orientation in

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[177] Peter A. Weismantle, Gregory L. Smith and Mohamed Shariff, "Burj Dubai: An Architectural Technical Design Case Study," *The Structural Design of Tall and Special Buildings*, November 5, 2007, 345.

[178] Weismantle, Smith and Shariff, 345-346.

[179] "How the Burj was built," *Construction Week*, January 16, 2010, http://www.constructionweekonline.com/article-7400-how-the-burj-was-built/1/ (Accessed February 2, 2014).

[180] Weismantle, Smith and Shariff, 345.

the use of tallest buildings[181] represented by mixed use as the main use and focusing on residential and hotel use. As shown in Figure 34, using the upper floors as a residential area in Burj Khalifa creates what I noted above as the suppression of the side effects of height occupation in the upper floors. Designating the upper floors for the residential units contributes to supporting the total function of the tallest building through reducing the percentage of the occupation, decreasing the floor areas, adding flexibility in partitioning the areas and reducing the total loads, which reflect in turn on the safety and comfort factors. In fact, this helps in offering a reasonable occupation in the upper floors where the distance between the center core and the edge of the floor plate becomes shorter.

Suppression as synergy in the technical ensemble of Burj Khalifa also takes on another dimension through isolating any system that could affect negatively the main direction of the whole ensemble, as for example the sewage system. Because of the size of Downtown Dubai and the new development of the area, most projects were constructed at approximately the same time, which delayed finishing the infrastructure of Downtown Dubai at the time of Burj Khalifa. Thus, there was no connection of Burj Khalifa to the Dubai sewage network. This obstruction threatened the existence of Burj Dubai, especially with the approaching completion date. The idea of synergy emerges through suppressing the individual role of the sewage system from its role within the whole ensemble. In other words, Burj Khalifa has a sewage system that is integrated with the other systems in the technical ensemble, but the sewage system itself does not work properly because of extrinsic influences—the viability of the city's sewage network. The solution was to supersede the individual role in the whole ensemble by finding a temporary collection system, then using trucks to carry the collection to the treatment plant.[182] This would seem an insufficient solution if we make a comparison between the ambition to build the world's tallest building and the lack of provision of a basic service at the site. However, the solution of this matter did not go beyond a kind of temporary solution, which was superseded by

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[181] Refer to 'Changing the Function of the Tallest Building' in chapter two.

[182] Lauren Kelley, "World's Tallest Building Has One Major (Stinky) Problem," *AlterNet*, December 28, 2012, http://www.alternet.org/news-amp-politics/worlds-tallest-building-has-one-major-stinky-problem (Accessed May 21, 2014).

160 and above	Mechanical
156–159	Communication and broadcast
155	Mechanical
139–154	Corporate suites
136–138	Mechanical
125–135	Corporate suites
124	*At the Top* observatory
123	Sky lobby
122	*At.mosphere* restaurant
111–121	Corporate suites
109–110	Mechanical
77–108	Residential
76	Sky lobby
73–75	Mechanical
44–72	Residential
43	Sky lobby
40–42	Mechanical
38–39	Armani Hotel suites
19–37	Armani Residences
17–18	Mechanical
9–16	Armani Residences
1–8	Armani Hotel
Ground	Armani Hotel
Concourse	Armani Hotel
B1–B2	Parking, mechanical

Figure 34: Matrix of Burj Khalifa’s floors shows the function of each one

the permanent connection to the sewage system when the sewage network of Downtown Dubai was completed later.

The evolution of the technical object in Burj Khalifa depends on a process of differentiation among the parts (systems) such as that which occurs in the architectural, structural, and mechanical systems, and in their concretization in the ensemble. These two aspects are tied to each other; differentiation is possible because it allows for integration into the functioning of the ensemble of the correlative effects of the overall functioning, which are only partially corrected by palliative measures unconnected with the performance of the principal function. As indicated previously, the structural system of Burj Khalifa depends mainly on the buttressed core, which in addition to its function as resistance against twisting (torsion) load is used to decrease the loads of the array of the floors 162 times (the number of the floors) on the internal structural walls and perimeter columns. Redistributing the gravity loads on the structural elements will participate significantly in decreasing the total settlement of Burj Khalifa during the next 50 years to 65 centimetres[183] and changing the dimensions of the structural walls to reasonable dimensions and reducing the loads on them. This contributes to dealing with the structural walls as though they were ordinary walls, whose thicknesses are about 30 to 40 centimetres and in exceptional cases 60 centimetres, separated between spaces such as between units and each other, and, simultaneously, enhancing the possibility to find openings in walls for architectural purposes. Using the structural walls as partitions between two residential units solves jointly the issue of sound insulation and security matters, which are considered cultural issues according to Dubai requirements. The structural walls obviate Burj Khalifa optimally from bearing extra dead loads that come from using heavy materials such as concrete blocks in the case of using the steel structure system.

[183] For more details about this issue refer to page 75.

Function and Specialization of Systems in the Ensemble

The specialization of each system in Burj Khalifa is a specialization of positive, functional, synthetic unity, free of unlooked for secondary effects which could drain the functioning of the whole system. The technical object progresses by interior redistribution of functions into compatible units, eliminating the chances of internal conflict. Specialization, for Simondon, "is not achieved function by function but synergy by synergy. What constitutes the real system in a technical object is not the individual function but the synergetic group of functions."[184] The concrete technical object is one that is no longer in conflict with itself, one in which no secondary effect compromises the functioning of the whole nor is omitted from that functioning. In the abstract technical object of Burj Khalifa each system is designed to perform a specific function. The concretization of a technical object is the organization of a functional system in its total functioning starting with this principle: the redistribution of functions is brought about in the network of different structures in abstract as much as in concrete objects where each system performs a number of functions. For instance, as I explained earlier, the structural system has architectural functions such as internal structural walls and external form, and mechanical functions such as in the elevator system. But in the abstract technical object each system performs one essential and positive function that is integrated into the functioning of the ensemble, which in the example of the structural system is to provide stability to the world's tallest building. In the concrete technical object all the functions of Burj Khalifa performed by the structure of the ensemble are positive, essential, and integrated into the function of the ensemble; and the marginal consequences of the functioning that are eliminated or attenuated by correctives in the abstract object become positive stages or aspects in the concrete object. The functioning scheme incorporates the marginal aspects, and the consequences that were uninteresting or harmful become functional links.

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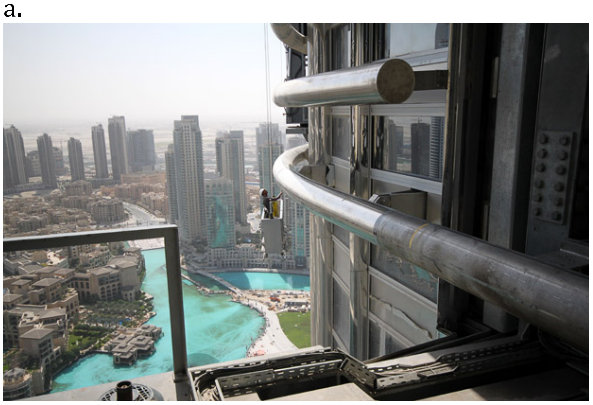
[184] Simondon, *On the Mode of Existence of Technical Objects,* 30.

Technical Knowledge in the Construction of Burj Khalifa

The concrete technical object at the ensemble level is a coherence of systems in which mutual actions take place according to the laws of science. The aim of technical design cannot be perfectly realized in the construction of the object unless it is identified with technical knowledge. Systems can be grouped into coherent ensembles so as to exchange information with each other through the human interpreter—the designer. Let's take the curtain wall system in Burj Khalifa as an example to demonstrate the relation between the usage, the layout of the floors, the structural form and the design of the envelope system itself.

The pattern and characters of the curtain walls are not similar throughout the building; their variety depends on the location and the proportion and relation with other systems. For instance, in the mechanical floors, which are distributed at five places throughout the height of Burj Khalifa, the structural outriggers are included in these floors, so there is a concentration on the structural action at these levels (Figure 35). The curtain walls are changed to be like horizontal ribbons enhancing the function of the floors as well as the architectural effect as joints between the steps of the external form. The stainless steel is increased to 70 percent and there is a decrease in the percentage of the glass and openness to 20 percent and 10 percent, respectively. Indeed, these ribbons are employed as external belts to fasten the whole building at different levels. Furthermore, these ribbons include 200 millimeter polished stainless steel tubes that are used for the cleaning equipment. To avoid keeping the window washing rigs outside all the time, the stainless steel tubes continue inside the enclosure at the central spine where the window washing rigs are stored. A careful glance at the pattern of the curtain walls throughout the Burj Khalifa shows there is trend to unify the module of the envelope except below the third floor and at the spire level, which starts above 560 meters. The changes in the first three floors are to free the bottom of Burj Khalifa from the model of the curtain wall in order to provide special treatments at the entrance level. At the spire element, the matter seems different. Because of the small perimeter of the spire and to give it a circular shape and structural stiffness at that height, the lower part is confined on the mullions with a short

a.



b.

c.

d.

e.

Figure 35: Curtain walls system of Burj Khalifa

distance between them and a decreased width of the glass panels, while the upper part is made completely from stainless steel. Now, how can we be sure that the curtain wall can resist the pressure of the wind loads? In fact, a module of the curtain wall was built as per the meteorological data that were collected from Dubai Airport over the last 50 years. In a wind tunnel and with cutting-edge technology in the aerodynamic analysis program, each part of the curtain walls was verified until its performance reached the adequate theoretical model of the performance of the curtain walls (Figures 36-37). The second stage was to transfer that model to a real model under the same circumstances before starting the prefabrication. As a matter of fact, it was a big challenge to provide the same circumstances of the environment at the high levels of Burj Khalifa on the ground to examine the curtain walls. The solution was to make two mock-ups: one for the modular curtain wall and another for the curtain at the mechanical floors, and to use a jet engine to produce the required wind force on the ground (Figure 38). The levels of the wind analysis that were done to examine the abstract theme of the effect of the winds on Burj Khalifa seem incredible, like those that can be seen only in the science fiction films.

Part of understanding the concretization of the technical object lies in realizing it as an intermediate place between the natural object and its scientific representation. The abstract technical object of Burj Khalifa is the translation of its ensemble through scientific notions and principles that at a basic level are unconnected with one another. But they are connected by sequences of convergence in order to reach what is being looked for. Therefore, the technical object of Burj Khalifa is not a physical natural system; it is the physical translation of an intellectual system. For this reason, it is a consequence of knowledge and thought that is capable of prevision and creative imagination. In this imagination, the designer can group different systems in reversed conditioning in one ensemble and create coherence in the total function.

Technical Perfection in Burj Khalifa

From the above, arguing for the technical object as a regime gives hints about the relation between any product and technical perfection. In other words, the level of technical relations between different systems at the ensemble level makes us wonder: how

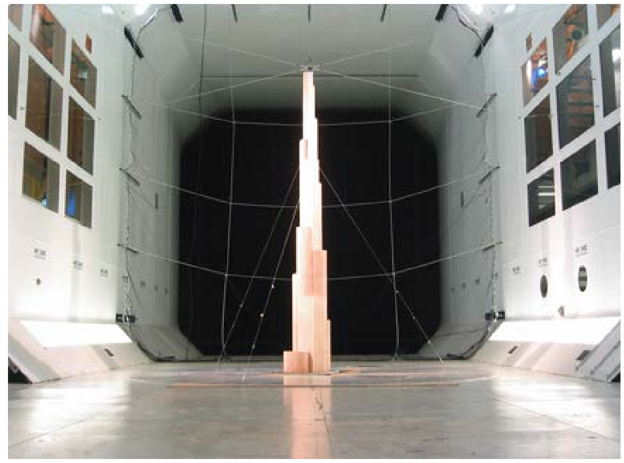


Figure 36: 1:50 scale model of top of Burj Khalifa in NRC's 9m x 9m wind tunnel

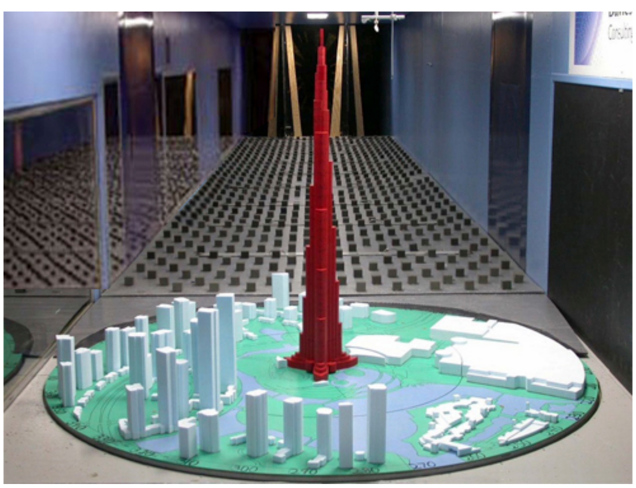


Figure 37: Burj Khalifa: Cladding pressure test model at 1:500 scale, shown in wind tunnel

Figure 38: Burj Khalifa: Test of the mock-up assembly

can we understand the technical perfection in Burj Khalifa? Because if we realized the technical achievement in Burj Khalifa as the world's tallest building, it would carry implicitly a recognition of its technical perfection.

Technical perfection appears as a value in the concretization of the ensemble of Burj Khalifa. Technical perfection is a practical quality or, at the very least, the material and structural support of practical qualities; hence, a good system is not merely a well-made and well-shaped tool.[185] The system is not made of matter and form only; it is made of technical elements developed in accordance with a certain scheme of functioning and assembled as a stable structure by the manufacturing process.[186] And the system retains in itself the result of the functioning of a technical ensemble.[187] During the preliminary stages of designing Burj Khalifa, the problem of settling, which is a natural behavior of buildings over time, appeared to be an obstruction against the height of Burj Khalifa. As I explained earlier, the shrinking of the total height was decreased to 65 centimeters for the next 50 years. Nevertheless, within the main direction of the function of the ensemble, adjusting the height of each floor 4 millimeters extra made the result reach the perfect situation of the world's tallest building not only in its construction but also for the future. Another example, in constructing an ordinary tall building, monitoring the verticality can be done through using the standard tools that generally do not differ from those used for low-rise buildings. But this issue becomes critical in supertall buildings, especially with a building reaching to 828 meters in height. In construction, an assumption appears as a visualization of the matter as an abstract object that is then transferred to a real entity in the construction. Ordinarily, assumptions are relatively easy in ordinary buildings, but in Burj Khalifa the validity of the assumptions seems complicated. Namely, in Burj Khalifa, no one can assume any margins of error in the assumptions. From this point of view, the assumption of the behavior of the elements and the accurate verticality of them, whether as individual elements or as the whole building, seems freed from tolerance. What is referred to as technical perfection represents finding a mechanism that helps to check the assumptions

[185] Simondon, *On the Mode of Existence of Technical Objects,* 61.
[186] Ibid. 62.
[187] Ibid.

periodically through the integration between the Structural Health Monitoring Program (SHMP) and GPS technology. The construction method of the project includes monitoring the behavior of the building during all stages by the SHMP to confirm the building's structural behavior during construction and throughout its lifetime by using more than 700 sensors embedded in its structure.[188] According to Ahmad Abdelrazaq, the construction manager of Burj Khalifa, the system uses *total stations,* which refer to fixed reference points with known coordinates and critical to the precision of the entire procedures[189] (Figure 39). The monitoring includes, for Abdelrazaq, the following: "pile load dissipation into the soil, raft foundation settlement, column shortening at the core wall and exterior columns, column/core wall total strains due to gravity load at several levels during construction, lateral displacement of the tower during and after construction, tower movement and dynamic characteristics during construction at one location, tower movement (displacement and acceleration) and dynamic characteristics during the lifetime of the project at seven locations along the height, wind speed and profile, temperature variation, and humidity along the height, fatigue behavior of the pinnacle." He adds, "These extensive survey and monitoring programs have, since their inception, provided real time feedback into the actual in-situ material properties, the tower's dynamic characteristics, and structural behavior and response under wind and seismic excitations."[190] The vertical and lateral movements of Burj Khalifa are tracked with the help of a satellite-based global positioning system. Besides, the GPS system, which is connected with three satellites for GPS measurement, is utilized to maintain the margin of error for verticality of Burj Khalifa to within 5 millimeters and to keep the project moving forward at a rapid pace.[191] From a careful glance at the above examples, we can find that the technical perfection emerges out of forms and materials. It is a practical quality or, at the very least, the material and structural support of practical qualities.[192] It is a development of the whole ensemble in

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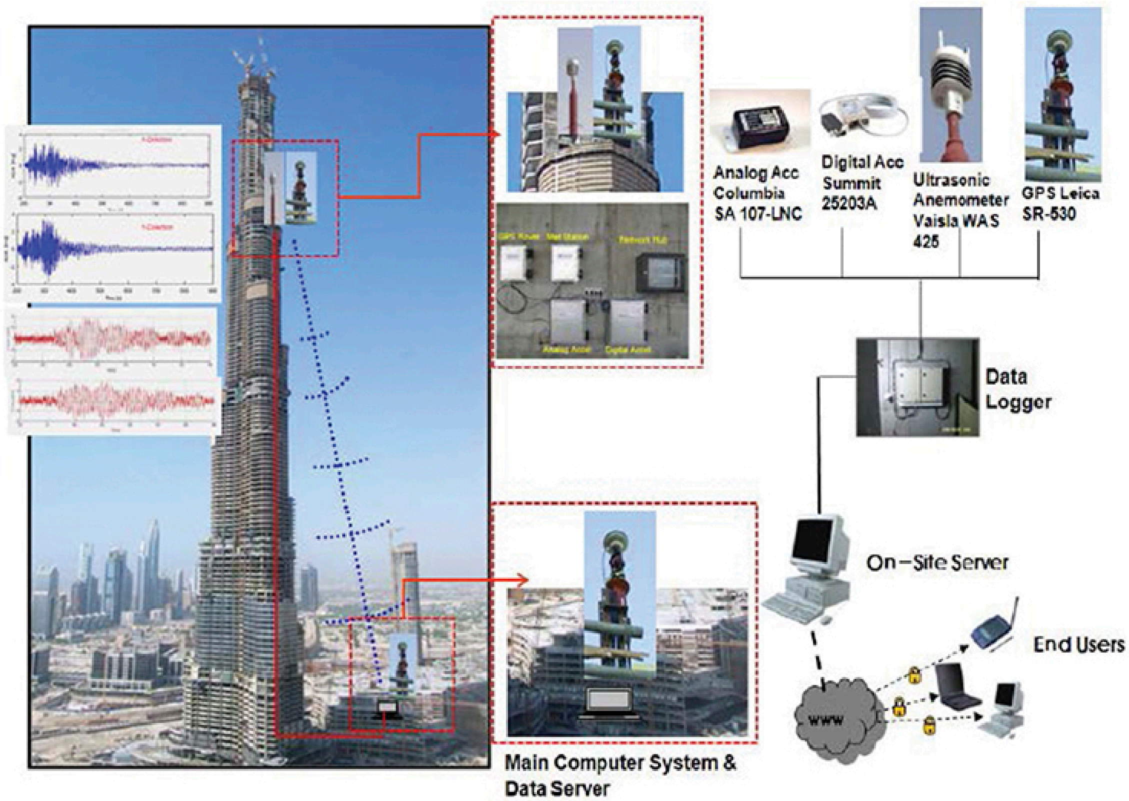
[188] "Burj Dubai: World's Tallest Building: Facts & Figures," *Sefindia*, www.sefindia.org/forum/download.php?id=1261 (Accessed May 30, 2014).

[189] Ahmad Abdelrazaq, "Validating the Structural Behavior and Response of Burj Khalifa: Synopsis of the Full Scale Structural Health Monitoring Programs," *CTBUH*, www.ctbuh.org (Accessed June 12, 2014).

[190] Ibid.

[191] "Burj Khalifa," *Samsung C&T - Engineering and Construction Americas*, http://www.samsungeca.com/projects_burj_khalifa.html (Accessed June 27, 2014).

[192] Simondon, *On the Mode of Existence of Technical Objects,* 61.



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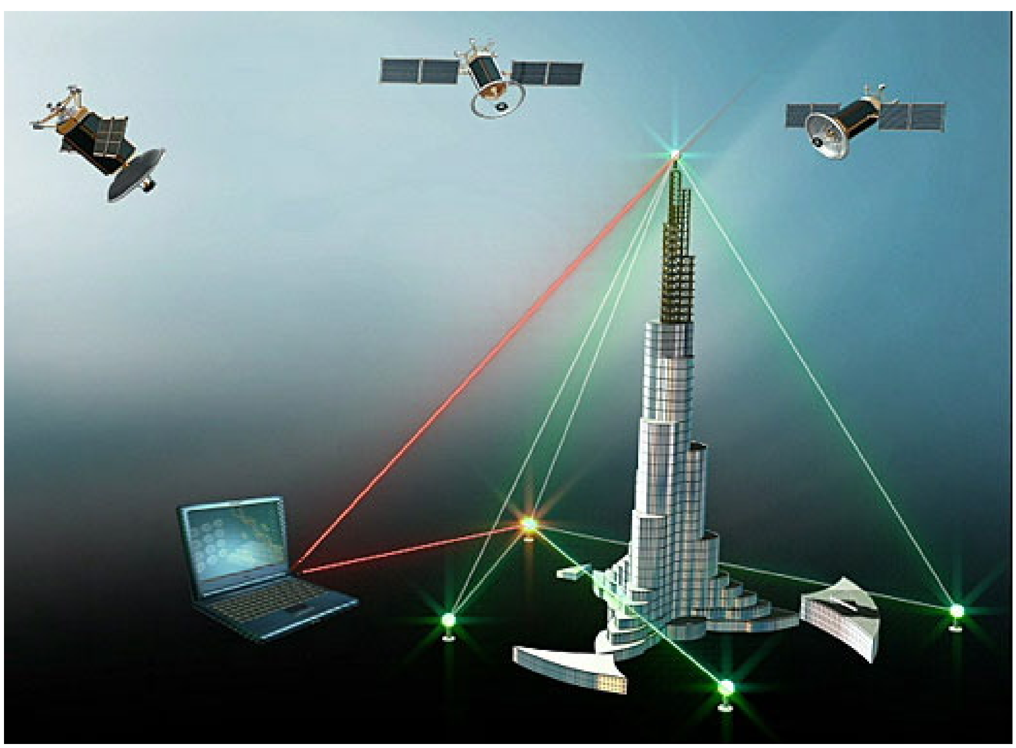

b.

Figure 39: Burj Khalifa: Structural Health Monitoring System

accordance with a certain scheme of functioning and assembled as a stable structure by the manufacturing process.

The Role of the Architect/Engineer

In 1956, Frank Lloyd Wright announced his proposal for the world's tallest building at one mile high (5280 feet) in Chicago, which was later known as The Illinois (Figure 40). According to a 22-foot-tall sketch of his giant building, the structure was to be steel and glass, with 528 floors extending out from a central core like branches on a tree trunk. In his presentation of the project, Wright focused on the advantages of adopting this kind of architecture especially in high densities areas.[193] Within the general trend at that time, his description of the benefits and feasibility of the project was as expected. What was remarkable in that presentation is the spirit to achieve that edifice. Wright insisted that the mile-high building was no joke; it was *thoroughly scientific*.[194] The challenge to achieve these kinds of projects makes them close to inventions, which go beyond the ideas and means available at a particular time. If we leave The Illinois aside and examine all of the world's tallest buildings that came later, we find the same sensation in dealing with the topic of the world's tallest buildings. The concept of the world's tallest buildings is the concept of invention inclusively. However, the concept of the inventor in relation to the world's tallest building sounds peculiar. In the philosophy of the technical object,[195] imagination emerges as the influential factor for understanding the role of the inventor in Burj Khalifa, which seems closer to the role of the architect, designer, engineer or all of them. The key in realizing the role of the inventor lies in what we stated earlier about the cognitive schema and the origin of the technical object. Although the first spark of Burj Khalifa, which was provoked by Sheikh Mohammed, unfolded an imagination of the project, it did not reach more than being a vision. What makes Burj Khalifa reach 828 meters in height as the world's tallest building is technical imagination.

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[193] John R. Schmidt, "Frank Lloyd Wright's mile-high building," *WBEZ 91.5*, August 25, 2011, http://www.wbez.org/blog/john-r-schmidt/2011-08-25/frank-lloyd-wrights-mile-high-building-90793 (Accessed May 2, 2014).

[194] Ibid.

[195] I discussed the inventor in the philosophy of the technical object in chapter one, refer to 'The Inventor and the Technical Object".

a. b.

Figure 40: Burj Khalifa and The Illinois

Understanding the imagination means realizing the role of the elements in a technical object, where, according to Simondon, they are the carriers of the technicity.[196] Thus, for Simondon, "the inventor does not begin *ex nihilo,* starting with matter and giving it form, but with elements that are already technical."[197] Consequently, the challenge lies in inventing the schema that is capable of incorporating the elements into one coherent technical object. Therefore, it is not strange when we find Baker, the innovator of the structural system of Burj Khalifa, describing the structural system as a combination of very conventional systems arranged in a unique manner.[198] The unique manner is an invention that is capable of combining different elements in one technical ensemble through compatibility. Through the invention, the inventor has a sense of the future but by way of the present. There is nothing except an imagination of what could be workable.

The perception of innovation in the philosophy of technical objects makes adaptation, as an action by the inventor, undesirable in realizing the relations among various systems or elements because adaptation, according Chabot, does not create new dimensions.[199] Further, she adds, "it does not change the means of becoming; it merely repeats and reproduces."[200] This seems clear from my discussion of the concretization of the structural system as a technical object. Although it is a composition of ordinary elements—core, columns and slabs, we are confronted by an innovated world's tallest building ever. The emergence of Burj Khalifa as a technical object makes its architecture take on a unique direction in its manifestation; it is established by new kinds of coherence of different systems in a new ensemble.

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[196] Simondon, *On the Mode of Existence of Technical Objects,* 63-64.

[197] Ibid., 64.

[198] Josephine Minutillo, "Beyond Limits," *Architectural Record*, August 2010, http://continuingeducation.construction.com/article.php?C=690&L=5 (Accessed July 2, 2014).

[199] Chabot, 10.

[200] Ibid.

Conclusion

More than four years ago, and specifically on Monday, January 4, 2010, I was one of the thousands who attended the inauguration of Burj Khalifa, which was granted this name by Sheikh Mohammed on that day instead of its previous name, Burj Dubai. It was a solemn ceremony and exceptional in every sense of the word. Nevertheless, the general atmosphere was tainted by a state of grief. There had been general dissatisfaction since the global economic crisis that struck Dubai at the end of 2007, more than two years before the completion of Burj Khalifa. Everyone was waiting that day to see if Dubai would be able to complete this edifice, especially with the size of the debt accumulated from its under-construction projects, which amounted to $26 billion in 2009. Unsurprisingly, the economic factor was addressed strongly in any discussion about the world's tallest building—Burj Khalifa. In addition to the economic power of Dubai, there were a number of potentials that participated effectively in the appearing of Burj Khalifa, which assumed two dimensions of influence: horizontal and vertical. Horizontally, it was a moving of potentials centrically towards one place—Dubai. It was a concentration of the energy in what Simondon calls a privileged place that carried the seed for the emergence of Burj Khalifa. On the other hand, there was a vertical direction of potentials that pushed Burj Khalifa for supreme achievement. A deep examination of the emergence of Burj Khalifa shows that these potentials participated in saturating the milieu to bring about the emergence of the world's tallest building. However, they did not go beyond producing repeated products—the tallest building or a repetition of the world's existing tallest buildings with a margin for a few changes. The real transformation in Burj Khalifa as an exceptional achievement is a technical evolution due to the intrinsic potentials of its system.

Realizing Burj Khalifa as a technical object provides a comprehensive conception of the real role of technology in its evolution. In this sense, Burj Khalifa as a technical innovation evolves in the direction of its concretization as a technical object by virtue of internal necessity—technical evolution. Thus, Burj Khalifa is not a repetition of another model or a copying of other successes, but it is the innovation of a unique regime within a specific milieu.

Understanding Burj Khalifa as a technical object stems mainly from comprehension of its end as the world's tallest building, which determines its boundaries and level. Looking at it from this angle reveals the value of its height as the key to realizing it as a technical object. The systems that compose Burj Khalifa are gathered together in order to synergize this value within the whole ensemble. This orientation makes understanding what is required from Burj Khalifa as architecture, or specifically as a mixed-use megatall building, to be enclosed implicitly within the main direction of its being as the world's tallest building.

The technical object is a result of an abstract work in the organization of various systems, and a theater of a number of relations of reciprocal causality among these systems. The systems of Burj Khalifa in the abstract, as much as in the concrete objects perform various functions. In the abstract technical object, there is a positive function of each system that integrates it into the functioning of the ensemble, while in the concrete technical object all the functions that are performed by the systems are integrated into the function of the ensemble as the world's tallest building. At the same time, the marginal consequences that are undesirable or harmful become functional links in the system. Those that are eliminated or attenuated by correctives in the abstract object become positive stages or aspects in the concrete object.

The key of the emergence of Burj Khalifa as the world's tallest building lies in the invention of the structural system as a technical object. It is an imagination of the regime of the structural system in the future through the abstract paradigm to tune the effect of the winds on the building. At the moment the structural elements (buttressed core and setbacks) synergize and a circular causality pushes strongly, the real meaning of the invention emerges and the technical object is concretized. The potentials in the three sets (the two elements of the buttressed core and the setbacks) have been interlinked in such a way to generate a kind of energy along the whole building to confuse the winds and at the same time to regulate the transfer of the other loads into the ground effortlessly, allowing the tallest building to stand up independently. The moment of invention is when the three sets of potentials click together, coupling into a single continuous system. At that instant, a new regime of functioning has suddenly leapt into existence in a situation of self-solidarity. It is a creation of what looks like a reverse storm around the whole building as it hits and fades into the original winds. The leap of the new regime of the structure in this uncommon way makes us ask questions about the resources of that regime. The multifunctions of the structural elements were not in effect before crossing the threshold. In other words, the potentials of the structural elements were not affected in the past (before crossing the threshold). There is no place except the future. The influence of the potentials of the structural elements that leaped to create the new regime is invented in the future. Even if the main direction to achieve the ability of the system to rise stably for 828 meters is through the structural system, the success of the whole system as a technical object is subject to the synergies from all the systems of Burj Khalifa, such as the elevator system, the curtain walls system, the mechanical system etc. Through imagination and a sense of the future, the inventor (architect/engineer) combines compatibly different elements or systems into one abstract technical ensemble, which is concretized as a technical object in the invention process. Each system in the technical object can best complete its own function as a perfectly finalized instrument; and, simultaneously, it is completely oriented towards the performance of the whole function of the ensemble to achieve the emergence of the world's tallest building ever. Identifying Burj Khalifa as a technical object means that we recognize it as a pure invention, which in turn does not refer to the traditional hylemorphic notion in which a person has an idea and then builds something that corresponds to that idea; rather, it is the birth of a new regime occasioned by the operation of recurrent causality involving the actual operation of the technical object itself.

After all, the emergence of Burj Khalifa as a technical object requires invoking the initial question, "What is the significance of arguing for Burj Khalifa as a technical object?" In fact, it is prejudicial to say that there is limited significance to this issue. Examining Burj Khalifa as a technical object has opened up new horizons going beyond realizing and interpreting its technical innovation. Indeed, it is a new approach to comprehending architecture in all its aspects. There is a new visualization of the design and designer, technique and technology, systems and regime, innovation and production, object and milieu, abstract and concrete, extrinsic and intrinsic potentials, and many others. All these aspects can be grasped from understanding the philosophy of the technical object, which can make us re-think seriously architecture and our vision for understanding it in general.

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