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Innovations in Building A Safer World
(Building Codes)

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Table of contents:

1	INTRODUCTION.....	3
2	AIM.....	3
3	BUILDING CODES.....	4
3.1	INTRODUCTION TO BUILDING CODES	4
3.2	DEFINITION OF BUILDING CODES.....	6
3.3	BUILDING CODES IMPLEMENTATIONS IN BUILDING LIFE CYCLE.....	8
3.3.1	<i>Design phase</i>	8
3.3.2	<i>Construction phase</i>	8
3.3.3	<i>Operational phase</i>	9
3.3.4	<i>End of life for the building</i>	9
4	DISCUSSION OF FACTORS AFFECTING BUILDING CODES	10
4.1	CONSTRUCTION USAGE	10
4.2	CONSTRUCTION TYPE (MATERIAL USED AND FIRE RESISTANCE).....	12
4.3	ZONING.....	13
4.3.1	<i>Hazards and earthquake zoning:</i>	13
4.3.2	<i>Weather zoning:</i>	15
5	FACTORS AGAINST APPLYING BUILDING CODES IN MIDDLE EAST.....	17
5.1.1	<i>Unawareness.</i>	17
5.1.2	<i>Cost & time consuming</i>	17
5.1.3	<i>Low income</i>	17
5.1.4	<i>Non qualified employers at municipality.</i>	17
5.1.5	<i>Conflict of interest.</i>	18
5.1.6	<i>Different culture in construction at the Middle East.</i>	18
5.1.7	<i>Following international codes for different conditions.</i>	Error! Bookmark not defined.
6	REFERENCES AND BIBLIOGRAPHY.....	19

List of Tables:

TABLE 4-1 CONSTRUCTION USAGE FACTOR EFFECT ON BUILDING CODES THROUGH THE LIFE CYCLE PHASES.	11
TABLE 4-2 EFFECT OF CONSTRUCTION TYPE ON THE BUILDING LIFE CYCLE.....	13
TABLE 4-3 ZONING (HAZARDS AND EARTH QUICK) FACTOR EFFECT ON BUILDING CODES THROUGH LIFE CYCLE PHASES.....	14
TABLE 4-4 ZONING (WEATHER) FACTOR EFFECT ON BUILDING CODES THROUGH LIFE CYCLE PHASES.....	16

1 Introduction

Building Codes and regulations of building construction are not a recent phenomenon. It can be traced through recorded history for over 4000 years. This provides evidence that people have become increasingly aware of their ability to avoid catastrophic consequences of building construction failures.

For codes to be effective, an understanding and cooperative relationship must exist between building officials and all parties involved in the construction industry such as homeowners, contractors, consultants, developers, as well as urban planners. Codes must be responsive to government's need to protect the public.

Building codes are needed by the public to protect against disasters due to fire, high winds, rain, floods, structural collapse, and earthquakes. Although no building code can eliminate all risks, but following building codes can reduce risks to an acceptable level.

It is believed by the author that up till the time of writing this paper there is no serious action taken in the Middle East countries to improve level of construction. There are Building codes, they are not updated or innovated to walk parallel with the rapid rising technology. In addition, there is no strict rules to follow building codes, local authorities depend on one part which is the consultant to ensure quality and safety.

2 Aim

The aim of this paper is to define, investigate, and discuss how building codes can lead to a safer world.

3 Building Codes

This section will introduce the definition of building codes, types of building codes, and the factors affecting implementation of building codes.

3.1 Introduction to Building codes

Building codes can be considered started with the first house ever built. Using for wooden columns or sticks to hold a leaf cover on top can be considered a building code, as if three columns were used the cover roof wood fall down and harm whoever is under. Egyptians were the first to use the codes and standards in building their pyramids (1300 AD) which is the most famous pyramids all over the world, the engineering knowledge used in such structures indicated type of civilization and building codes considered while construction. Pyramids of France, Greece, India, North American pyramids, Petra of Jordan, and Al-Hambra of Granada, all are structures proves existing of codes and standard during the history of construction.

In order to document the very long history of building codes, the first building code was considered the code of Hammurabi (IRAQ - 1795 BC – 1750 BC) who was the first Dynasty king of the city state of Babylon. Hammurabi is known for the set of laws called Hammurabi's code, which was one of the first written codes of law in history, these laws were written on stone tablets founded in 1901. Hammurabi's code specified the following [1]:

- 229 - *If a builder builds a house for someone, and does not construct it properly, and the house which he built falls in and kills its owner, then the builder shall be put to death.*
- 230 – *If it kills the son of the owner, the son of the builder shall be put to death.*
- 231 – *If it kills a slave of the owner, then he shall pay, slave for slave, to the owner of the house.*
- 232 – *If it ruins goods, he shall make compensation for all that has been ruined, and inasmuch as he did not construct properly his house which he built and it fell, he shall re-erect the house from his own means.*

- *233 – If a builder builds a house for someone, even though he has not yet completed it, if then the walls seem toppling, the builder must make the walls solid from his own means.*

The Romans and Persian followed the Babylon, then Islamic empire construction gave a high standard quality of codes either for construction, design, plumbing, safety, air distribution. The Castle of Al-Hambra in Granada shows the top quality Islamic engineers reaches during the golden age of Islamic empire (8th to 13th century) before the industrial revolution in Europe which results in releasing the following:

- Baltimore building code in 1859.
- London building act (England - 1894).
- The public Health Act (England - 1875)
- Metropolitan Building Offices was established (England - 1845).
- France released law (1852-1870) which limits buildings height to five or six stories at most.
- Release of International Building Code (USA – early 1900s).

Since the Early 1900s, United States took the lead for improving building code which was based on model building codes developed by three regional model code groups:

1. Building official code Administrators International (BOCA), Were used in the east coast and the Midwest of the United States.
2. Southern Building Code congress international (SBCCI).
3. International Codes Building Officials (ICBO), which covered the west coast of the United States.

The nation's three model code groups decided to combine their efforts in 1994 and formed International Code council (ICC) in order to develop codes that would have no regional limitations. The result became to sight in the 1997 when the first edition of the International Building Code (IBC) was published [5].

3.2 Definition of Building Codes

Building codes can be generally defined as a set of rules that specify the minimum acceptable level of safety, standard of design, and construction quality for any structure. Technically, it can be defined as a compendium of laws and regulation setting minimum safety standards and arranged in systematic manner (Codified) for easy reference. It embraces all aspects of the building construction starting from structural, fire items, as well as the plumbing, electrical, and mechanical systems. The main purpose of the building codes is to protect public health, safety and the occupants of building structure.

Building codes become a law when formally registered by the appropriate authority. They are generally intended to be created and applied by architects and engineers, but in some countries they are applied by approved inspectors. These inspectors can be safety inspectors, environment scientists, real estate developers, contractors, construction material manufacturers.

Building codes generally include most of the following:

- Zoning types approved by legal authority laws.
- Specification of components used in the building structure.
- Various allowable installation methodologies.
- Exit and escape locations and sizes.
- Qualification of companies constructing the work.

In most countries, building permits are required for any new construction, renovations, and demolition projects, these permits ensures that local authority has checked on applying building codes for any type of construction.

There are several significant advantages of following standard building codes, such as:

- Building codes ensures that construction in your community complies with the zoning by-law, including proper land use and appropriate set backs from property lines.

- Building codes professionalize drawings, plans, and specifications before and through construction.
- By forcing the need of building permits, it should ensure compliance with all required codes and local by-law by having qualified inspectors on site at appropriate stages of construction.
- Building codes improves safety for owners and users of any construction.
- Building codes saves owner money by preparing special standards for the uses of the building by first time construction.
- Following Building codes can increase the value of the construction through time, by avoiding future problems that might arise by not following codes.
- Following energy building codes will sure decrease consumption of energy through running phase of the building life cycle.

Unfortunately, in the Middle East countries (except Dubai), there is no strict building inspections to follow standard building codes through construction phase. Once the license to build is issues, there will be no more relation between contractor and municipality or any local authority; client depends totally on the consultant to ensure safety and quality.

3.3 Building Codes implementations in building life cycle.

3.3.1 Design phase

The design phase is the first and most important stage for the building. In this phase, the designer decides which materials to be used, type of elements to be constructed, and the operational system of the building after being constructed. I.e. the design phase is connected to all the other phases in the life cycle of the building. The designer decisions have a fundamental effect on all other aspects of a buildings life, particularly occupation and eventually deconstruction and disposal.

Building Codes used in this stage should include designing codes, specifications, material codes, plumbing, electrical, Mechanical and energy codes, fire resistance code, and disabilities codes.

Moreover, the cost of the project should be taken in consideration through this phase; adopting a fire alarm system for high rise building should be totally different than fire alarm system for neither a shopping mall nor private villa project. Type, budget, location, use of different projects should be taken in consideration

3.3.2 Construction phase

Construction is the second task after the design, construction engineer should follow the design from the previous phase; contractors are considered to be main responsible for this stage. Health and Safety codes, as wells as, Quality control codes are the major codes to be followed through this phase. Following Building Codes in this stage should be strictly observed by the local legal authority to insure safety of workers and future owners.

Proper building codes should provide alternative methods for contractors to follow building code regulations; the procedure of construction concrete building is totally different than steel structure building or wooden type construction.

3.3.3 Operational phase

This phase is considered to be after the construction is finished and the building is submitted, i.e. this phase is the only time where the users will be able to use the building. For this reason, it is important that the building will be comfortable for users; therefore, the building codes are important to provide the best quality for the client.

3.3.4 End of life for the building

This is the last phase in the buildings life where it is impossible or undesirable to extend the life of buildings through adaptation or refurbishment. Usually this phase comes after fifty years of using the building; it depends on the standards of each country, and the usability of the buildings, or sometimes the life for building ends when the life for new building is needed to be started at the same location¹. Existing of building codes can assure or increase the age of any construction.

¹ Most of the old buildings in city centres were removed to build new buildings.

4 Discussion of Factors affecting Building codes

In this section Factors that affect building codes will be discussed to have a good understanding of how importance these factors in each building life cycle.

4.1 Construction usage

This is one of the major factors affecting application of building codes in all the construction life cycle phases. There are many construction usage categories; they are classified as some of the following:

- Business offices.
- Industry.
- High-Hazard Industry.
- Institutional.
- Mercantile buildings.
- Storage buildings.
- Residential.
- Simple accommodation buildings.
- Mixed use.

The building code of high-hazard industry is stricter than building code for simple accommodation building as for fire fighting and factor of safety used during the design phase, level of quality control in the construction phase, level of safety and maintenance precautions during third phase of the building life cycle.

Building Life cycle phases	Construction usage factor effect on building codes
Design phase	<p><u>Architectural Building codes</u></p> <ul style="list-style-type: none"> • Maximum spaces and areas. • Regulations of set back from property line. • Type of material to be used. <p><u>Structural Building codes</u></p> <ul style="list-style-type: none"> • Load assumptions. • Safety factors used in structural design. • Type of material to be considered. <p><u>Fire Fighting codes</u></p> <ul style="list-style-type: none"> • Type of material to be used. • Fire fighting system and time rating.

	<p><u>Electromechanical Codes</u></p> <ul style="list-style-type: none"> • Type of materials to be used. • Detailed of connections. • Amount of power requirement. • Amount of water and services requirements.
Construction phase	<p><u>Health & Safety codes</u></p> <ul style="list-style-type: none"> • Type of safety precautions and safety exists. • Type of details and quality control inspections.
Operational phase	<p><u>Maintenance and running operational codes</u></p> <ul style="list-style-type: none"> • Frequent of maintenance. • Type of safety exists and precautions.
End of life for the building phase	<p><u>Sustainability codes</u></p> <ul style="list-style-type: none"> • Considered maximum age of building. • Frequent of inspection for the safety of building.

Table 4-1 Construction usage factor effect on building codes through the life cycle phases.

4.2 Construction type (material used and fire resistance).

Different construction types can have different standards and codes to be followed, the construction type can be classified by structural system (Concrete, steel, timber), height, functioning of the structure, and many other characteristics of building.

Building Life cycle phases	Construction type factor effect on building codes
Design phase	<p><u>Architectural Building codes</u></p> <ul style="list-style-type: none"> • Maximum spaces and areas. • Type of material to be used. <p><u>Structural Building codes</u></p> <ul style="list-style-type: none"> • Load assumptions. • Type of foundation. • Safety factors used in structural design. • Type of material to be considered. <p><u>Fire Fighting codes</u></p> <ul style="list-style-type: none"> • Type of material to be used. • Fire fighting system and time rating. <p><u>Electromechanical Codes</u></p> <ul style="list-style-type: none"> • Type of materials to be used. • Detailed of connections. • Amount of power requirement. • Amount of water and services requirements.
Construction phase	<p><u>Health & Safety codes</u></p> <ul style="list-style-type: none"> • Type of safety precautions and safety exists. • Type of details and quality control inspections.
Operational phase	<p><u>Maintenance and running operational codes</u></p> <ul style="list-style-type: none"> • Frequent of maintenance. • Type of safety exists and precautions.
End of life for the building phase	<p><u>Sustainability codes</u></p> <ul style="list-style-type: none"> • Considered maximum age of building. • Frequent of inspection for the safety of building.

	<ul style="list-style-type: none"> • Sustainable demolition.
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Table 4-2Effect of construction type on the building life cycle.

4.3 Zoning

Zoning factor can be used according to different inputs, such as:

4.3.1 Hazards and earthquake zoning:

As discussed in the world organization of building officials (WOBO) report (*Hurricanes – 2006*), zones expected to face hurricanes has totally different safety building codes than building codes specified for building in an earthquake zones. Building standards of construction in New Orleans are different than standards needed in building a construction at Amman- Jordan or Mecca – Saudi Arabia.

In earthquake zone pad foundation might be specified in building codes to allow structure to flex and sway, while in Hurricanes and flood zones hydraulic piles foundations might be specified to reduce damage of the structure.

The effect of this category can be simplifies in the following table:

Building Life cycle phases	Zoning – Hazards and Earth quick effect on building codes
Design phase	<u>Architectural Building codes</u> <ul style="list-style-type: none"> • Maximum height of Building. • Maximum amount of floors. • Type of material to be used. <u>Structural Building codes</u> <ul style="list-style-type: none"> • Safety factors used in structural design. • Type of foundations used. • Type of material to be considered. <u>Fire Fighting codes</u> <ul style="list-style-type: none"> • Type of material to be used. • Fire fighting system and time rating.
Construction phase	<u>Health & Safety codes</u> <ul style="list-style-type: none"> • Type of safety precautions and safety exists.
Operational phase	<u>Maintenance and running operational codes</u> <ul style="list-style-type: none"> • Frequent of maintenance. • Type of safety exists and precautions.
End of life for the building phase	<u>Sustainability codes</u> <ul style="list-style-type: none"> • Considered maximum age of building. • Frequent of inspection for the safety of

	building.
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Table 4-3 Zoning (Hazards and earth quick) factor effect on Building codes through life cycle phases.

4.3.2 Weather zoning:

This factor is related at some parts with the hazards factor, but, on the other hand, this factor heavily effect types of building codes needed in the design phase, type of winds, Wind speed, temperature, and Moisture are characteristics to be considered in building codes.

- Type of winds and wind speed:

This part is related to the hazards, high speed winds or sandy storm can be very destructive to any structure. Natural hazards and forces are much dangerous and important than other factors affecting building codes.



Figure 4-1 Sandstorm attacking Riyadh – Saudi Arabia.

- Temperature & Moisture:

Building codes varies according to temperature zoning as well as Moisture conditions; building standards facing snowing weather are different than the codes considering temperature of 50°C.

Unfortunately, there are not any strict regulations in Middle East concerned of protect against weather and energy saving. It is believed by the author that different type of

insulation, type and even color of paints, should be will specified in the building codes and standards.

The regulation effected by the weather factor can be simplifies in the following table:

Building Life cycle phases	Zoning – Weather effect on building codes
Design phase	<p><u>Architectural Building codes</u></p> <ul style="list-style-type: none"> • Layout of building. • Shape of Building. • Type of material to be used. • Degree of detailing. <p><u>Structural Building codes</u></p> <ul style="list-style-type: none"> • Safety factors used in structural design. • Loading assumptions. • Type of material to be considered. <p><u>Electromechanical codes</u></p> <ul style="list-style-type: none"> • Type of material to be used. • Capacity and power required. • Energy saving provisions.
Construction phase	<p><u>Health & Safety codes</u></p> <ul style="list-style-type: none"> • Type of safety precautions and safety exists. • Concrete temperature required precautions while pouring.
Operational phase	<p><u>Maintenance and running operational codes</u></p> <ul style="list-style-type: none"> • Frequent of maintenance. • Type of safety exists and precautions.
End of life for the building phase	<p><u>Sustainability codes</u></p> <ul style="list-style-type: none"> • Considered maximum age of building. • Frequent of inspection for the safety of building.

Table 4-4 Zoning (Weather) factor effect on Building codes through life cycle phases

5 Factors against applying Building codes in Middle East.

5.1.1 Unawareness.

Regrettably, unawareness by the owners, engineers, or building officials for the importance and advantages of applying Building code in construction is a major factor for not having strictly building codes, permits, and inspections in the Middle East region countries.

5.1.2 Cost & time consuming.

The cost is one of the most challenging issues in Middle East construction; in general, the concept of Building codes, standards, inspections, when introduced in construction, usually gives the impressions of increasing cost and time which result in reducing profit. It is true that applying building codes will add more cost, but on the other hand, Building codes saves for the long term of the construction through maintenance and running phase, it helps stabilizing the value of the construction asset for future trading, in addition of saving energy and running costs.

5.1.3 Low income.

This factor indirectly affects applying building codes, as some of public with low income will be forced to intend in have “under table” services, which will lead to cheating in construction materials, and very low quality and standards of constructing.

5.1.4 Non qualified employers at municipality.

As mentioned earlier, Building codes should be updated in order to follow the rapid innovated technology, and to achieve such status, employers of municipality should be well trained and educated to apply new features of any building code.

5.1.5 Conflict of interest.

In most of middle east countries construction sector, its hardly to define who is responsible for applying building codes, Ministry of public works, Municipal of corporation, and Society of engineers do share the responsibilities of setting building codes, monitoring applications of building codes, and announcing the use of the building codes.

5.1.6 Different culture in construction at the Middle East.

Due to the past invasions of Arabic countries and different cultures and knowledge of different colonials, as for construction, this reason affects the building codes of these countries, although some countries like Jordan created their own building codes, but it was based on the British code. While in Syria they are following the French code, in Egypt they have their own code which was based on both British and German code, Saudi Arabia building code is following the International building code.

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