ARE SAFETY MEASURES ADDRESSED IN THE DESIGN OF OUR RESIDENTIAL BUILDINGS?

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ABSTRACT
Architects and engineers play the most significant role in assuring safety in the design of buildings. However, in the absence of enforced local building safety codes and standards, many Saudi buildings, especially residential type, are designed without considerations for safety measures. According to statistics, residential buildings in Saudi Arabia account for the highest percentage of buildings burnt among all types of buildings. This is mainly due to the lack of safety measures in the design of such buildings complicated by poor construction/installation methods and lack of safety awareness among residents. The objective of this paper is to present the results of the assessment of safety practices in the design of residential buildings in Saudi Arabia and to identify common safety deficiencies. It also presents a systematic safety compliance checklist based on existing local safety instructions and international safety codes and standards. The checklist use is intended to ensure compliance with the minim safety requirements in the design of residential buildings.

Key Words*: Fire safety, safety design, residential buildings, Saudi Arabia*

INTRODUCTION
Design for safety should always be addressed in the early stages of the design process. Construction documents should facilitate understanding of building safety requirements by all those involved in the design and construction of buildings. In fact, safety errors in building design can be corrected much more easily at the drawing board and at a less cost than would be the case after the fact corrective action. In addition, safety design should be an integral part of the design of all building systems.

The implementation of safety measures early in the design stage can reduce unnecessary hazards in buildings. People often rationalize accidents by blaming the victims' carelessness, but they ignore the efforts which are needed to determine genuine causes (Kalin, 1994). Furthermore, some tragic accidents and injuries happen when people deviate from well-known published requirements. For example, in apartment buildings with one means of egress, one can see on the exterior facade that a lot of people are using window barriers or obstructions on all the openings, which prevent escape in the event of fire. Critical time could be lost by fire fighters in looking for windows blocked with steel barriers, with no assurance that anyone is in that house or room. Furthermore, some of these steel barriers are not removable very easily which might result in a serious fire problems while trying to remove these obstructions. In fact, most accidents have a specific cause or a combination of causes that can be anticipated. As stated by Treror Klets "accidents do occur not because no one knows how to prevent them, but because available knowledge is not applied" (Brown, 1995).
It is known that building related accident prevention steps start on the drawing board. Architects must always identify and implement potential safety measures in their design whenever possible. For example, the shape and size of the building can affect the start, growth and spread of fire inside and outside the building. Also an understanding of the importance of

trading aesthetics for safety is very important, such as the designing of a large glass entrance without having red or any dark color identification to reduce the possibility of accident and injury. In addition, the architectural features in structural glazing might present safety problems when improper lighting, for example, makes it difficult for pedestrians to distinguish between open door-ways and adjacent glass panels.
It is observed that dead ends and dark corners add to the possibility of accidents. The designer should pay attention to the elimination of these elements in his design. The design of safe exits has become an important concern. The authorities and firemen must determine the real escape time in any building, so they divide the building into fire areas by limiting the volume (Sanytor, 1981).

Designers should always give attention to usual accidents occurring in buildings resulting from common sources such as poor lighting intensity, electrical wiring, floor covering, stairway dimensions and handrail and finding improvements that could reduce this type of accident. For example, electrically grounded circuits and double insulation on appliances, give greater protection against electrical shocks. (Ponessa, 1992).

According to some studies, designers rarely take formal safety education or training, and they don't use "safety" resources used by safety practitioners (Main, 1994). Design engineers, at best, follow some approach to safety, which incorporates safety factors, use a safety checklist and complies with codes and standards. Main and Frants (1994) suggest that "effort should not be directed toward motivating engineers to include safety issues in their designs, but rather focused on methodologies available for use by designers". Also safety professionals should be involved in building design at the earliest possible stage and provide technical expertise to improve safety measures. Designing for safety should not be left solely to one individual source.

Examining building fire accidents in Saudi Arabia clearly indicates that fire is a major hazard in residential buildings, which accounts for the highest percentage (69.3%) of the number of buildings burnt in the reported four years average among all types of buildings (CDS, 1996).

Architects and engineers play the most significant role regarding safety responsibility in the design of buildings. Although they know that designing for safety is vitally important it is not clear yet how to go about establishing, incorporating and enforcing safety measures in buildings. The most readily available information to building designers in Saudi Arabia about this subject is the safety instructions for different types of buildings provided by the Department of Safety and Industrial Security (GCDA, 1990). The questions then become: how much consideration was given to safety in the design of existing Saudi buildings? And what measures should be taken to ensure safety in the design of new residential buildings?

The objective of this paper is to present the results of a field assessment conducted to study the current safety practices in the design of typical residential buildings in Saudi Arabia and to identify common safety design deficiencies as currently practiced by professionals. It also presents a systematic safety compliance evaluation in the form of a simple checklist based on existing local safety instructions and international safety codes and standards.

DESIGNING FOR FIRE SAFETY

There are three important phases of actions in order to minimize fire hazards namely: fire prevention, fire protection and safety awareness and education. Fire prevention requires that the building layout, structure, materials, contents, equipment and systems must be designed, selected and maintained in such a way as to render them as free as possible from being causes of or aids to combustion. In general fire prevention in buildings starts at the drawing board, where fire safety- related errors in the original design could be corrected much more easily and at far less cost than would be the case with after-the-fact corrective actions. Fire prevention measures must then be realized by making sure that the actual construction complies with the approved safety measures. Completed buildings should, therefore, be checked for significant revisions or alterations in construction and/or occupancy that might affect safety.

Fire protection as the second phase of action involves fire detection, control and fighting. Fire protection necessitates the development and use of design methods for detecting and controlling fires so as to limit the probability of damage from fire, if one does start. A fire detection system is an installation where detectors are connected to a control unit and where signals are transferred from each detector to the control unit. These devices include warning alarms for occupants, activated door closing systems, and fire extinguishing systems. There are different types of fire/smoke detectors such as gas detectors, smoke detectors, flame detectors, and heat detectors. All these detection devices are sensitive to smoke, light and heat. For example, it is important in the design stage that designers consider the provision of the adequate detection system and the required number of detection devices in the building according to relevant codes and standards. The optimum fire protection depends on many factors, such as the size and complexity of building materials being handled, accessibility for fire fighting, potential for spread and escalation of fire, potential for exposure of people to injury or loss of life as well as on the effectiveness of fire protection systems such as fire extinguishing systems, smoke control and smoke and heat venting systems. In the third phase of action, occupants and users of buildings must be made aware of safety measures and fire prevention/protection methods and systems available in buildings and continuous awareness or training programs should be conducted for their education in matters related to fire safety.

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SURVEY DESIGN AND ADMINISTRATION

A questionnaire was designed to assess the current practices followed by design offices in Saudi Arabia with respect to addressing safety in the design of residential buildings. The questionnaire was divided into seven sections as follows: General information; Municipality requirements; Civil defense requirements; Clients role; Fire and smoke control measures;

Electrical safety measures; and General safety measures. This questionnaire was distributed to most of the well-known design offices in the major cites of Riyadh, Dammam, Al-Khobar, Makkah, Jeddah and Taif via mail and through personal visits to some of those design offices. Out of the 112 distributed questionnaires, a total of 102 (i.e. 91%, a high response rate) completed forms were received. There were 32 responses from the Eastern Province (Dammam and Al-Khobar), 23 from Riyadh, 19 from Makkah, 18 from Jeddah and 10 from Taif. The general information of the survey revealed that the average years of experience of design participating offices was 13 years. 46% of the respondents expressed themselves as architectural engineers, 31% as architects, 21% as civil engineers and 2% as mechanical and surveying engineers. This indicates that 77% of those responsible for addressing safety measures in the design of buildings are architects and architectural engineers. From the survey, it was found that residential projects constitute 75% of the total projects for 58 % of the design offices, while 27% indicated that residential projects account for between 50-75 % out of their total design projects. Out of these residential projects, villas and low-rise apartment buildings are between 50 and 75 % while high-rise apartment buildings constitute less than 25 %.

The data obtained from the questionnaire was analyzed utilizing the Statistical Analysis System (SAS), which consists of a family of software applications that provide a variety of data processing and analysis capabilities [SAS, 1994]. The questionnaire was designed so that the respondents can chose from the five ranked options of *always, most of the time, sometimes, rarely,* and *never*. Then, for the purpose of the analysis, a four-point scale was used and a weight was given to each of these evaluation criteria as follows: *always*: 4 points, *most of the time*: 3 points, *sometimes*: 2 points, *rarely*: 1 point, *never*: 0 point. Each of these evaluation criteria was ranked according to the frequency of responses to each and a calculated safety measure score value was given to each question. Then, the Effectiveness Index (EI) of each question was calculated according to the following formula:

$$\text{Effectiveness Index (EI)} = \left(\frac{\sum_{i=1}^{n} f_i w_i}{\sum_{i=1}^{n} f_i} / 4 \right) x100$$

Where:

f_i = frequency of responses to criterion i,
w_i = weight of responses to criterion i, and
n = number of answer choices = 5

Different ranges of classifications have been used for the grouping of the average values and the indices used to reflect survey respondents' ratings. For the purpose of this research, the same approach of a university student 4.0 GPA scale was used to classify, the average value (AV) and Effectiveness Index (EI) into six categories as follows:

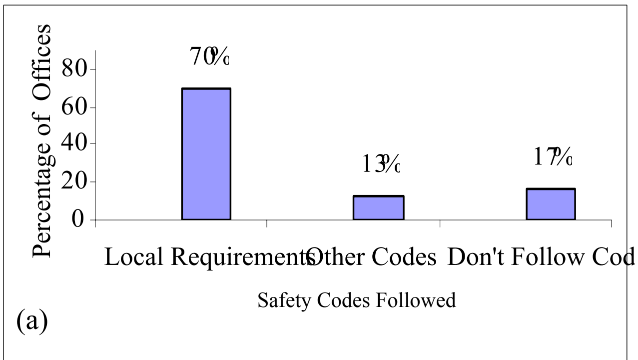
Extremely effective:	$3.75 \leq \mathbf{AV} \leq 4.00$	or	$93.75 \leq \mathbf{EI} \leq 100$
Highly effective:	$3.50 \leq \mathbf{AV} < 3.75$	or	$87.50 \leq \mathbf{EI} < 93.75$
Very effective:	$3.00 \leq \mathbf{AV} < 3.50$	or	$75.00 \leq \mathbf{EI} < 87.5$
Moderately effective:	$2.50 \leq \mathbf{AV} < 3.00$	or	$62.50 \leq \mathbf{EI} < 75.0$

Ineffective: $2.00 \leq \mathbf{AV} < 2.50$ or $50.50 \leq \mathbf{EI} < 62.5$

Extremely ineffective $\mathbf{AV} < 2.00$ or $\mathbf{EI} < 50.0$

DISCUSSIONS OF THE SURVEY RESULTS

Questions were asked to obtain information about three aspects namely: *The Safety Codes* that are usually utilized; *Authorities Responsible for Reviewing and Approving Safety Measures;* and *Critical Number of Units and Height of Building*. As shown in Figure 3(a), 70% of the surveyed design offices indicated that they utilize local safety requirements which are minimal safety instructions for different types of buildings prepared by the Department of Safety and Industrial Security of the GCDA. 17% indicated that they don't utilize any documented safety codes, and the remaining 13%, indicated that they follow other codes such as the UBC, 1997 and the National Fire Protection Association (NFPA) requirements. This indicates that majority of the design offices rely on the GCDA safety instructions/requirements.



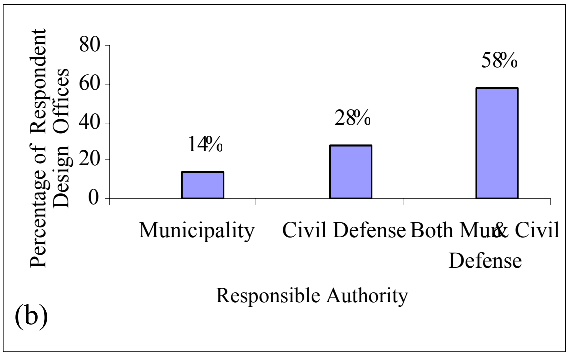


Figure 3. (a) Safety codes requirements that are utilized by the design offices (b) Authorities responsible for reviewing and approving safety measures in buildings

When inquired about who is responsible for reviewing and approving design safety issues, 14% of the design offices indicated that the municipality is responsible, while 28% indicated the GCDA to be responsible. However, the majority, 58%, indicated that both municipality and GCDA share the responsibility for reviewing and approving safety issues of their designs as shown in Figure 3(b). The municipality is mostly, concerned with requirements of the land use and regulations such as building height, setback, number of units, number of parking spaces, and the allowable built-up area, aesthetics, and other aspects such as the circulation and privacy. In addition, the municipality reviews the structural drawings to ensure structural safety, while the GCDA is the primary department concerned with checking compliance with fire safety aspects.

Municipality Requirements

Since the municipality approves all building permits, it is very important to know how building designers express their experiences in dealing with the requirements of the municipalities regarding safety in the design of residential buildings. The AV and EI of the analyzed survey related to municipality requirements in the design of the three types of residential buildings, namely villas, low-rise apartment buildings (LRAB) and high-rise apartment buildings (HRAB) were determined. All the responses related to the availability of municipality safety regulations or requirements in the design of villas and LRAB have an extremely ineffective EI of less than 50.0%, while HRAB have a highly effective EI of 82.8%. These results indicate that the municipality does not give as much consideration to safety aspects in the design of villas and LRAB as it does to HRAB. However, when asked how often safety issues mean only structural safety to the municipality authorities, most of the design offices specified that this is often the case. The EI of responses addressing this particular issue were 67.8%, 67.3% and 74.0%, for villas, LRAB, and HRAB, respectively. This also reveals that safety of building structural systems is a primary concern for the municipality. Fire safety, however, has less priority when reviewing safety issues for approval allowing more flexibility to designers in implementing fire safety measures in their designs for villas and LRAB. However, for HRAB fire safety is one of the major municipality criteria for the design approval with an EI of 83%, while it is of much less importance for villas and LRAB with an EI of 32% and 38% for villas and LRAB, respectively.

Usually the implementation of any design regulations or requirements cannot be seen clearly unless related written documents or drawings are submitted to the concerned authority. Examining the practice of the design offices regarding the municipality submission requirements of design drawings for safety approval, the answers were extremely ineffective for villas and LRAB with an EI of 12% and 20.8%, respectively, while the case was moderately effective for HRAB with an EI of 65%. These results indicate that most of the Saudi building design offices do not prepare safety drawings for villas and LRAB, while they do for HRAB. As a result, it can be concluded that the municipality and the design offices don't pay much attention to safety measures in the design of villas and LRAB, while greater attention is given to address safety measures in HRAB but not as effectively as it should be.

GCDA Requirements

Although the GCDA in Saudi Arabia publishes safety instructions for different types of structures including residential buildings as discussed earlier, the survey showed that most of the surveyed design offices are not aware of such safety regulations for villas or LRAB as indicated by the calculated Effectiveness Indices of 21.8% and 32.0% for villas and LRAB, respectively, representing an extremely ineffective rating. However, for HRAB, majority of the design offices are aware of the GCDA safety regulations as shown by the very effective rating (EI of 78.5%). This also indicates that the designers use these regulations in the design process of HRAB but not for villas and LRAB. This reveals that the design offices provide safety details to clients as much as required by the GCDA authorities. The Effectiveness Indices for how thoroughly the civil defense considers safety requirements in the design of villas, LRAB, and HRAB were 67.0%, 70.8% and 94.3%, respectively. This reveals that the civil defense inspects HRAB very thoroughly (extremely effective index of 94.3%) but for villas and LRAB the responses are characterized as moderately effective.

According to the results of the survey, it can be concluded that although there are safety regulations for villas and LRAB, the civil defense does not pay much attention to their enforcement. This explains why most of the surveyed design offices responded that they do not exist. On the other hand, most of the design offices are aware of and comply with the GCDA safety regulations for high-rise apartment buildings. Designers would have been more serious in considering safety measures if clear rules exist and are enforced.

Fire and Smoke Control Measures

The survey results showed that the two responses related to providing exits and proper circulation such as avoiding long travel distances to exits and avoiding dead ends or dead corners in the design of villas and LRAB have an EI between 62.5% and 75.0% (characterized as moderately effective), with the highest ranking among fire and smoke control measures. However, other aspects related to providing emergency exits, fire escape, dividing the building into fire cells or compartments, fire rated materials for walls and doors, fire retardation in the choice of external materials, location of portable/fixed fire extinguishing systems, access for fire fighters, smoke detectors, automatic sprinklers systems, fire water tanks and fire hoses, smoke shafts, integrated HVAC/smoke system for centrally air-conditioned buildings, pressurization of stair wells, fire alarms, emergency lights, exit signs, and exit doors swing direction are all dealt with in an extremely ineffective manner with an EI of less than 50%. One can conclude that there is a major deficiency in the consideration of fire and smoke issues in the design of villas and LRAB. Further analyses of some of the survey data revealed the following:

1. According to local safety requirements, two alternative escape possibilities should be provided for each apartment. One of these escapes can be a window where the civil defense rescue equipment shall have access. According to UBC the case is different where two exits are required if the number of occupant load is 10 or more and the window is used as a third escape route for a room but not for an apartment. An occupant load of 10 requires a minimum total floor area of 278.7 m^2 for two units and 185.8m^2 for three units or more. For a typical Saudi residential piece of land (20 x 20 m) with a maximum of 60% allowable built-up area, a two-story villa total area would be 480 m^2 which is greater than 278.7 m^2. This means that most of the villas and LRAB require two exits according to the UBC.
2. Portable fire extinguishers are required for two units, with at least two fire extinguishers for each floor according to the local safety requirements.
3. Smoke detectors should be installed in each sleeping room and at a point centrally located in the corridor according to the UBC.
4. Fire hoses should be available within a distance of not more than 25 meters from any point according to local safety requirements.

The analyses of the survey revealed that the above aspects are not being considered seriously in the design of villas and LRAB as reflected by the corresponding EI values and their poor respective ratings. However, in the case of HRAB these measures are dealt with slightly better than villas and LRAB where the issue of emergency exits has the highest ranking with an EI of 95.1%, extremely effective. The consideration of fire safety in the design stage, fire escape stairs, ease of access to exits in case of fire, and avoiding dead ends or dead corners, have an EI between 87.5%-93.5%, with highly effective rating. Other measures related to the location of portable/fixed fire extinguishing systems, smoke detectors, automatic sprinkler systems, fire water tanks and fire hoses, fire alarm systems, emergency lights, exit signs, exit doors, swing direction to the outside and avoiding long travel distances to exits, have effective indices between 68.75%-87.75% reflecting moderately effective rating.

Safety measures related to fire-rated materials for walls and doors, the specifications of fire retardation in the choice of external materials, access for fire fighters, smoke shafts, and venting, integrated HVAC/smoke control system for centrally air-conditioned buildings and pressurization of stair wells, all-indicated EI of less than 50.0% and can be considered as extremely ineffective. Generally speaking, fire and smoke issues in the design stage of HRAB is of major concern for the design offices as opposed to LRAB and the considerations of such safety measures increase with the increased height of the building.

SAFETY COMPLIANCE EVALUATION CHECKLIST

Architects and engineers know that designing for safety is important. However, in the absence of local Saudi safety codes or clear requirements at present, it is not clear to them how to go about incorporating sufficient safety measures in the design of residential buildings. The fact that most information available on this subject is only some safety instructions for residential buildings issued by GCDA makes it difficult for designers to comply with safety requirements.

The available local safety instructions refer to some international standards or codes such as NFPA or UBC, when more details are needed. Extracting safety details or information from international codes and standard is not an easy task for untrained architects and engineers. For these reasons, prioritized safety measures compliance checklist is proposed to be used along with an established and recognized safety codes for Saudi residential buildings as presented in Tables 1 and 2 for English and Arabic versions, respectively. It is hoped that the checklist would help to alleviate deficiencies in incorporating safety measures in the design of Saudi residential buildings. It is intended for use by building designers, safety authorities in the GCDA and municipalities. The safety compliance evaluation checklist was mainly extracted from local Saudi requirements, the Uniform Building Code (UBC, 1997) and the National Fire Protection Agency (NFPA, 199). The listed safety issues address minimum width of courts, the exterior finishes, the height and number of exits, and exit access distances and dimensions. Other measures also include features such as stairways and handrails, smoke detectors and fire extinguishing systems. The checklist does not cover all the required safety measures but identifies and guides the designer or the safety authority to ensure the minimum safety measures requirements for residential buildings. Designers still must refer to relevant safety codes and standards such as UBC and NFPA or any approved sources for more details and insights about specific safety requirements. This systematic safety compliance approach is not meant as a replacement to safety codes but rather a supplement to ensure clear and easy understanding of the minimum safety requirements in the design of Saudi residential buildings.

Table1: SAFETY COMPLIANCE EVALUATION CHECKLIST

Building: ________________________ Owner: ________________________

	SAFETY PARAMETER	**REQUIREMENT**					
1	BUILDING DENTIFICATION						
	No. of units in the building	Units					
	No. of stories (**NS**)	Stories					
	Total floor area (**TA**), Exclusive of vents shafts and courts	**TA= FLOOR AREA x No. OF STORIES =**					
2	**OCCUPANT LOAD**	For max. 2 units and three floor not exceeding 46.45 m^2		For 3 Units or more			
	Occupant load (**OL**) (UBC)	**OL** = **TA**/27.87 = -----------------------		**OL** = **TA**/18.58 = -----------------------			
3	**LOCATION ON PROPERTY**	**Min. width of courts having no windows**		**Min. width of courts having windows**			
	1 or 2 stories	0.91 m (UBC) ------------		2.0 m (LR) ------------			
	3 stories or more (UBC)	0.91 + 0.305(**NS** -2) = ----------------------		1.83 + 0.305(**NS** - 2) = ----------------------			
4	**EXTEROR FINISH**	**Non- combustible**		**Combustible**			
		No height limits		Maximum 2 stories			
5	**No. of exits according to UBC**	**OL** < 10	10 ≤ **OL** < 500	500 ≤ **OL** < 1000	**OL** >1000		
		1 Exit	**2 Exits**	**3 Exits**	**4 Exits**		
6	**EXIT ACCESS**	**Non sprinkled Bldgs.**		**Sprinkled Bldgs.**			
	Max. travel distance (UBC)	60.96 m		76.2 m			
	Max. dead end (UBC)	6.10 m		6.10 m			
	Max. distance from door in a unit to protected stair (LR)	10.0 m		10.0 m			
7	**EXIT DIMENSIONS**	**Min. width**		**Min. height**			
	Exit – access	1.20 m (LR)		2.03 m (UBC)			
	Apartment exit door	1.0 m (LR)		2.03 m (UBC)			
	Escape or rescue windows	0.91 m (UBC)		0.91 m (UBC)			
8	**EXIT IILLUMINATION**	**Minimum illumination level at ways leading to an exit is 10 lux (LR)**					
9	**Stairways (UBC)**	**Min. width**	**Min. headroom**	**Max. height between landing**			
		1.12 m	2.03 m	3.66 m			
		Min. height of risers	**Min. tread width**	**Max. Height of risers**			
		10.2 cm	27.9 cm	17.80 cm			
10	**HANDRAILS (UBC)**	**Min height**	**Max. Height**	**Max. Permitted spacing between bars**			

		86.4 cm	96.5 cm	10.16 cm sphere cannot pass through		
11	**FIRE ALARM SYSTEMS (UBC)**	Manual and automatic fire alarm system shall be provided in apartment houses three or more stories in height or containing 16 or more dwelling units.				
12	**SMOKE DETECTORS (UBC)**	Detectors shall be installed in each sleeping room and at a point centrally located in the corridor or area giving access to each separate sleeping area.				
13	**FIRE EXTINGUISHING SYSTEMS**	An automatic sprinkler system shall be installed throughout every apartment house three or more stories in height or containing 16 or more dwelling units (UBC) *.				
		In each floor of a unit, chemical fire extinguishers (6 kg) shall be provided (LR) with a maximum of 12 m travel distance to the extinguisher (NFPA)				
		For each floor, hose (2.5 in) shall be available within a distance of not more than 25 meters form any point (LR).				
14	**ELECTRICAL ISSUES**	Refer to National Electrical Code				

NS= Number of Stories, **A** = Floor Area, **TA** = Total Area, **LR** = Local Requirement, **OL** = Occupant Load, **UBC** = Uniform Building Code

* Although an automatic sprinkler system is a requirement in this case (i.e. 16 or more dwelling) by the UBC, it is a costly requirement and therefore builders and owners will tend to avoid installing it. Therefore, enforcement of other requirements and regular fire drills become then more essential.

جدول ٢: تقييم مدى مطابقة معايير السلامة في المباني السكنية

المبنى : ....

	عناصر السلامة	الوصف			
١	**مواصفات المبنى**				
	عدد الوحدات في المبنى	.... **وحدة**			
	عدد الأدوار	.... **دور**			
	مساحة مسطح البناء (بعد حسم الفراغات والمناور)	**مساحة البناء = مساحة الدور X عدد الأدوار** = ...م٢			
٢	**درجة إشغال المبنى**	**الحد الأقصى دورين ومساحة بناء الدور الثالث لا تزيد عن ٤٦٤,٥ م٢**	**ثلاثة أدوار أو أكثر**	**مطابق √**	**ملاحظات**
	درجة إشغال المبنى (در) حسب (UBC)	در=مساحة البناء ÷ ٢٧,٨٧	در=مساحة البناء ÷ ١٨,٥٨		

٣	**بُعد الإرتدادات**	أقل عرض الارتداد لواجهة لا توجد عليها فتحات	أقل عرض الارتداد لواجهة توجد عليها فتحات	**مطابق √**	**ملاحظات**
	دور أو دورين	**٠,٩١٤م (UBC) (.............)**	**٢,٠م (ت م) (.............)**		
	٣ أدوار أو أكثر (UBC)	**٠,٩١٤+٠,٣٠٥(عدد الأدوار-٢) (.............)**	**١,٨٢٩+٠,٣٠٥(عدد الأدوار-٢) (.............)**		
٤	**التكسيات الخارجية**	مواد غير قابلة للاحتراق	مواد قابلة للاحتراق		
		الحد الأقصى دورين	الارتفاع غير محدد		

٥	**عدد المخارج (UBC)**	درجة إشغال أقل من ١٠	درجة الإشغال ١٠< در ٠	درجة الإشغال ٠ >	درجة الإشغالثر من ١٠٠٠		
		مخرج واحد	مخرجين	ثلاثة	أربعة مخارج		

ت م : تعليمات محلية　　**د ر** : درجة الإشغال

UBC : كود البناء الموحد (Uniform Building Code)

	عناصر السلامة	الوصف		مطابق √	ملاحظات
٦	**المداخل والمخارج**	**لا توجد رشاشات مياه تلقائية**	**توجد رشاشات مياه تلقائية**		

	مسافة الانتقال (UBC)	**٦٠,٩٦٠ م ....**		**٧٦,٢٠٠ م.......**		
	أقصى مسافة لنهاية مغلقة(UBU)	**٦,٠٩٦ م ....**		**٦,٠٩٦ م ....**		
	أقصى مسافة من باب الشقة إلى سلم محمي (ت م)	**١٠ م**		**١٠ م**		
٧	**أبعاد المخارج**	**أقل عرض**		**أقل ارتفاع**		
	أبعاد المخارج	**١,٢٠ م (ت م)**		**٢,٠٣٢ م (UBC)**		
	أبعاد مخرج باب الشقة	**١ م (ت م)**		**٢,٠٣٢ م (UBC)**		
	أبعاد مخرج النافذة	**٠,٩١٤ م (UBC)**		**٠,٩١٤ م (UBC)**		
٨	**إضاءة المخرج**	أقل إضاءة تؤدي الى المخارج هي ١٠ لكس				
٩	**السلالم**	أقل عرض	أقل ارتفاع بين بسطتي السلم	أقصى ارتفاع بين السلمين		
		١,١١٨ م	**٢,٠٣٢ م**	**٣,٦٥٨ م**		
		أقل ارتفاع لقائمة الدرجة	أقل عرض لنائمة الدرجة	أقصى ارتفاع لقائمة الدرجة		
		١٠,٢ سم	**٢٧,٩ سم**	**١٧,٨ سم**		
١٠	**الدرابزين (UBC)**	أقل ارتفاع	أقصى ارتفاع	أكبر مسافة بين القضبان		
		٨٦,٤ سم	٩٦,٥ سم	١٠,١٦سم		
١١	**أنظمة جرس الإنذار**	يجب تركيب أنظمة جرس الإنذار اليدوية والأوتوماتيكية في كل عمارة تتكون من ٣ أدوار أو أكثر أو تحتوي على ١٦ وحدة سكنية				
١٢	**كاشف الدخان (UBC)**	يجب تركيب كاشف الدخان في كل غرفة نوم وفي منتصف الممرات				
١٣	**أنظمة إطفاء الحرائق**	يجب تركيب رشاشات المياه التلقائية في كل عمارة تتكون من ٣ أدوار أو أكثر أو تتألف من ٢٠ وحدة سكنية (UBC)				
		يجب توفير طفاية حريق بودرة كيميائية جافة ٦ كجم بكل طابق من طوابق المنزل وان لا تزيد مسافة الانتقال للطفاية عن ١٢ م				

		يجب تركيب بكرات خراطيم إطفاء في كل دور من أدوار المبنى الذي يزيد ارتفاعه عن دورين وفي حدود ٢٥ م من أبعد نقطة بالطابق.		
١٤	**السلامة الكهربائية**	مراجعة الكود National Electrical Code		

ملاحظة: هذه العناصر لا تشمل جميع متطلبات معايير السلامة .كما أن هذا الجدول لا يغني أو يعفي مستخدمة من الرجوع إلى أنظمة كود السلامة واتباعها كما تتطلبه الجهات الرسمية.

CONCLUSIONS AND RECOMMENDATIONS

Based on the results of this research, aimed at assessing safety measures in the design of residential buildings in Saudi Arabia, it is clear that, there is no specific fire safety code used by designers of residential buildings. Designers indicated that structural safety is the primary concern of the municipality for all types of residential buildings. Moreover, most of the designers are not aware of the regulations set by the GCDA authorities regarding safety measures intended for villas and LRAB. The GCDA does not require submission of safety drawings for these types of buildings. Therefore, the following recommendations are made:

1. Safety design in buildings must be laid out by qualified architects and engineers. Designers should give serious considerations to safety measures and adhere to local safety codes by providing construction documents which satisfy adapted safety requirements.
2. Issues of smoke and gas detectors, fire alarms, fire extinguishers, fire hoses, water tanks, fire escapes, exit door openings, emergency lighting and access for fire fighting teams, their vehicles and equipment, should be given serious attention by designers, planners as well as safety authorities when reviewing and approving the designs of residential projects. One of the procedures to enforce these requirements may be through cooperation between electric companies and the civil defense, where electricity supply to new buildings might not be allowed unless the owner provides a certificate from the GCDA or other related authorities confirming that the building design had compiled with safety requirements.
3. The safety compliance checklist proposed in this paper is highly recommended for use by designers and safety authorities as an easy compliance evaluation procedure to ensure minimum safety requirements in the design of new residential buildings. However, it must be understood that this compliance checklist does not, by any means, replace or free the concerned user(s) from referring to and complying with established safety codes requirements.

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