PRACTICES OF SAFETY DESIGN OF SAUDI RESIDENTIAL BUILDINGS

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ABSTRACT

The number of fires reported by the General Civil Defense Administration (GCDA) in Saudi Arabia indicates that fire is a major hazard in residential buildings, accounting for the highest percentage of buildings burnt. It seems that building designers and engineers do not give much considerations to the risk of fire in many of types of buildings. A considerable insight at safety measures in the design of buildings is therefore required. Architects and engineers play the most significant role assuring safety 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 is the safety instructions for different types of buildings provided by the GCDA. The objective of this paper is to present the results of a field assessment conducted to study the current safety practices in the design stage of residential buildings in Saudi Arabia and to identify common deficiencies in safety design. 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 minimal safety requirements in the design stage of residential buildings.

Keywords: *Safety design, fire safety, residential buildings, Saudi Arabia*

الملخص

يتعرض كثير من المباني بأنواعها المختلفة في المملكة إلى العديد من الحرائق سنوياً. وتشير الإحصاءات الواردة من المديرية العامة للدفاع المدني بأن المباني السكنية تتصدر القائمة في عدد الحرائق التي تتعرض لها سنوياً. وبالتالي فإن هناك حاجة إلى مراجعة معايير السلامة في تصميم هذه المباني. وبينما يلعب المعماريون، والمهندسون دوراً أساسياً في تحديد كفاءة عناصر السلامة في التصميم ، إلا أن كثير منهم لا يولي أهمية كبرى لاعتبارات السلامة في التصميم أو قد لا يملك القدرة على متابعة تنفيذها في المباني، وذلك في غياب الأنظمة الواضحة والصارمة حيال تطبيق هذه المعايير من قبل الجهات الرسمية. يهدف هذا البحث إلى تقديم نتائج دراسة ميدانية لمعاينة مدى تطبيق المصممين في المكاتب الهندسية بالمملكة لمعايير السلامة في تصميم المباني السكنية بالإضافة إلي تحديد عوامل القصور في هذا المجال. كما يقدم البحث قائمة مُبسّطة، و سهلة الاستخدام لتحديد أدنى معايير السلامة التي يمكن قبولها في تصميم المباني السكنية في المملكة وذلك استناداً على تعليمات السلامة المحلية ومعايير ومتطلبات السلامة العالمية.

1. INTRODUCTION

Designing for safety in buildings should be aimed at in the early stages of the design process. Construction documents should facilitate understanding of building safety requirements by those involved in the design and construction of buildings as well as by those who do not have enough exposure to safety education or training programs. 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, designing for safety should be an integral part of the design process of all building systems.

In Saudi Arabia, considerable insight at safety considerations in the design of buildings is required. Every year, deadly fires breakout in buildings because architects and engineers do not give much consideration to the possible risk of fire in many building types. The percentage of the average number of fires reported by the General Civil Defense Administration (GCDA) in Saudi Arabia for the years 1416 H (1996) to 1419 H (1999) indicates the significance of the problem as shown in *Figure 1* for different types of (burnt) property. *Figure 2* depicts causes of fire accidents for the same period.

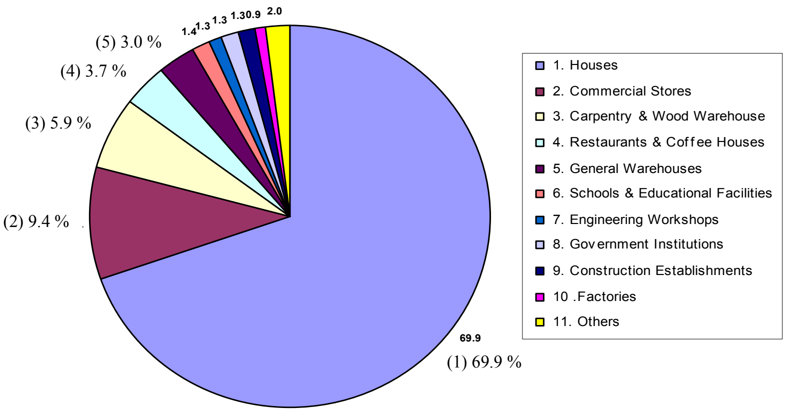

Figure 1.The percentage of building types (4-year average) burnt in Saudi Arabia *(GCDA, 1416H-1419H; 1996-1999)*.

Examining these statistics clearly indicates that fire is a major hazard in Saudi residential buildings and electrical shocks are the major cause of accidents. Fire accidents in residential buildings compared to other types of buildings have the highest number in the reported four years and the highest 4-year average which represents 69.3% of the total average of all types of buildings. This shows the need for assessing safety measures in the design of residential buildings in particular. It also requires the concerned authorities to ensure that designers as well as occupants strictly follow the requirements of safety measures.

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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 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 study 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 deficiencies in the design stage 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.

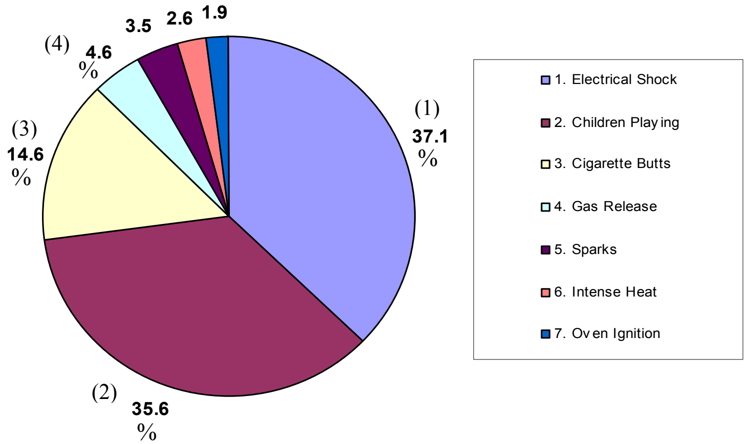

Figure 2. The percentage of causes of fire accidents (4-year average) *(GCDA, 1416H-1419H; 1996-1999).*

2. DESIGNING FOR FIRE SAFETY

In any building, the understanding of design for fire safety is very important to minimize fire hazards. There are three important phases of actions in order to minimize fire hazards namely: fire prevention fire protection and safety awareness or training programs. Fire prevention requires that the building structure, equipment and operation must be designed and maintained in such a way as to render them as free as possible from causes of or aids to combustion. In general fire prevention in buildings starts at the drawing board, where fire safety-related

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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 methods available in buildings and continuous awareness or training programs should be conducted for their education in matters related to fire safety.

3. SAFETY REQUIREMENTS

Recently in most cities of the Kingdom, the municipality requires all design drawings to be examined by the GCDA before issuing the building permits for commercial building projects or those consisting of four stories or higher in order to review and approve the considered safety measures and issues. Buildings with four stories or more are considered as high-rise buildings by the GCDA [Interviews with GCDA authorities in Dammam and Taif]. The GCDA, first, requests the submission of the building’s floor plans which should show at least two stairways. They also require special safety drawings that include fire detection layout, and the location of fire alarm bell, emergency lights, smoke detectors, sand bucket, fire extinguishers, fire hose cabinet, and fire water pumps. In light of these requirements, the designer proceeds with safety design based on his own experience and the available local safety requirements or instructions. Whether there is any approved safety code to be followed by the designers or GCDA in the Kingdom and whether safety requirements are implemented in reality in the absence of proper construction supervision and enforcement of such requirements are of great concern.

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At present, the Saudi Arabian Standards Organization (SASO) is developing a Saudi Arabian Building Code (SABC) [SASO, 1990]. The aim of this code is to identify an acceptable level of comfort and safety for building users. SASO started to establish code of Building Fire Protection and to develop the safety standards more than fifteen years ago [Basham, 1986]. Recently the Uniform Building Code (UBC, 1997) and the Uniform Fire Code (UFC, 1997) were adopted with some modifications that take into consideration the social, economic and technical aspects relevant to the Saudi society.

The UBC consists of a three-volume set. Volume I accommodates administrative, fire-and-life-safety, and field inspection provisions. Volume II considers structural engineering design provisions, and volume III contains materials testing, and installation standards. The UFC consists of a two-volume set. Volume I contains the provisions of the Uniform Fire Code while Volume II contains the provisions of the UFC Standards. Even with the adapted codes, it is not an easy task for local building designers to extract requirements and implement safety measures as included in these volumes without further clarifications, simplifications and necessary training.

4. SURVEY DESIGN AND ADMINISTRATION

A questionnaire was designed to assess the current practices followed by design offices with respect to addressing safety in the design of residential buildings. It 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 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 percentage of response) 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 average years of experience of engineering and design offices participating in the survey is 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 %.

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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 (Al- Hammad and Assaf, 1996):

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

Where, f_i = frequency of responses to criterion i, w_i = weight of responses to criterion i, and n = number of answering options = 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 the KFUPM student GPA scale was used to classify, the average value (AV) and Effectiveness Index (EI) into six categories as follows:

Extremely effective:	$3.75 \leq \textbf{AV} \leq 4.00$	or	$93.75 \leq \textbf{EI} \leq 100$
Highly effective:	$3.50 \leq \textbf{AV} < 3.75$	or	$87.50 \leq \textbf{EI} < 93.75$
Very effective:	$3.00 \leq \textbf{AV} < 3.50$	or	$75.00 \leq \textbf{EI} < 87.5$
Moderately effective:	$2.50 \leq \textbf{AV} < 3.00$	or	$62.50 \leq \textbf{EI} < 75.0$
Ineffective:	$2.00 \leq \textbf{AV} < 2.50$	or	$50.50 \leq \textbf{EI} < 62.5$
Extremely ineffective	$\textbf{AV} < 2.00$	or	$\textbf{EI} < 50.0$

5. 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

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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 requirements.

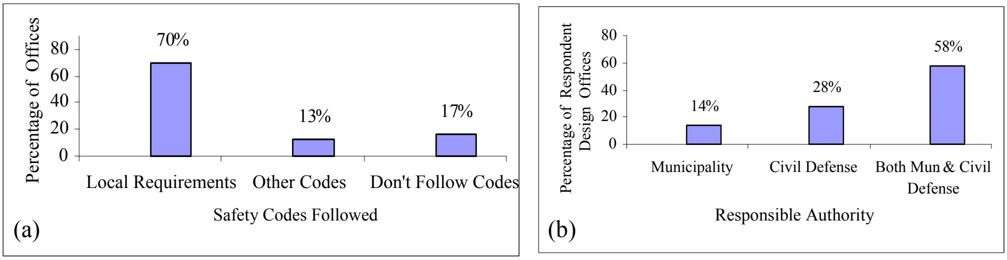

Figure 3. (a) Safety codes requirements that are utilized by the design offices (b) Authorities responsible for reviewing and approving safety measures in buildings

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 height, setback, number of units, number of parking spaces, and the allowable built-up area, aesthetics of the elevation, 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.

5.1 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 building (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

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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 by 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. 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 regulations or requirements cannot be seen clearly unless a written document or drawings are submitted to the concerned authority. Examining the practice of the design offices whether the municipality requires submission 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 designers 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.

5.2 GCDA Requirements

Although the GCDA in Saudi Arabia publishes safety instructions for different types of buildings including residential buildings as discussed earlier, the survey showed that most of the design offices are not aware of such safety regulations for villas or LRAB as indicated by the determined Effectiveness Indices of 21.8 and 32.0 for villas and LRAB, respectively, resulting in 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 civil defense inspects HRAB very thoroughly (94.3%, extremely effective) but for villas and LRAB the responses are characterized as moderately effective.

According to the results of the survey, it can be concluded that the civil defense does not pay much attention to safety measures in the design of villas and low-rise apartment buildings. Therefore, most of the design offices responded that there are no regulations, while there are regulations from the GCDA authorities regarding safety issues for villas and lower rise apartment buildings. On the other hand, most of the design offices are aware of GCDA regulations and they indicated there are safety regulations by the civil defense for high-rise

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buildings and that they submit their designs to the civil defense for safety approval. Designers would have been more serious in considering safety measures if clear rules exist and are enforced.

5.3. 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%, with the highest ranking among fire and smoke control measures characterized as moderately effective. 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 civil defense rescue equipment shall have access. According to UBC the case is different. 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 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 reveal that the above aspects are not being considered seriously in the design of villas and LRAB as reflected by the corresponding EI values and respective ratings. However, in the case of HRAB these measures are dealt with slightly better than

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villas and LRAB. 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, considering 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, indicated all EI less than 50.0% and can be considered as extremely ineffective. Fire and smoke issues in the design stage of HRAB is of major concern for the design offices as opposed to LRAB. In general the considerations of these safety measures increased with the increased height of buildings.

6. SAFETY COMPLIANCE EVALUATION CHECKLIST

Architects and engineers know that designing for safety is important. However, in the absence of local 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.

These 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 standard is not an easy task for untrained architects or engineers. For these reasons, prioritized safety measures compliance checklist is proposed to be used along with an established and recognized safety codes, for residential buildings constructed using concrete structures in Saudi Arabia as shown in Appendix A. It is hoped that the checklist would help to alleviate deficiencies in incorporating safety measures in the design of 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 requirements, the Uniform Building Code (UBC, 1997) and the National Fire Protection Agency (NFPA, 199). The aspects 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.

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Designers still must refer to safety codes 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 residential buildings.

7. CONCLUSIONS AND RECOMMENDATIONS

Based on the results of this research, aimed at the assessment of considering safety measures in the design of residential buildings in Saudi Arabia, it can be concluded that there is no specific safety code used by designers for residential buildings. Designers indicated that structural safety of buildings 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. Municipality and civil defense authorities should have local safety codes for all types of buildings. These codes should provide detailed safety requirements and regulations with clear guidance for easy incorporation by designers/architects, owners and occupants.

2. Municipality and civil defense should require the submission of safety drawings for all types of buildings, and the civil defense should examine all of them to ensure that all safety requirements and/or regulations have been met before issuing building permits.

3. 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.

4. 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 electricity 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.

5. The GCDA needs to conduct continuous safety awareness and educational programs to the public.

6. 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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Appendix A: 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			

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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.

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