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Leakage of building basements in Kuwait: extent and causes

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ABSTRACT

Attention to quality of waterproofing materials and construction practices is frequently lacking in the construction of basements in Kuwait. As a result, leakage of building basements is a widespread problem. To develop effective guidelines for waterproofing building basements, it was necessary to establish background data on local conditions regarding the leakage problem by investigating waterproofing materials, construction practices and actual leaking basements.

Waterproofing materials from as many as eleven countries are available on the local market, suggesting a broad range in the quality of the materials. Improper construction practices are identified with regard to the handling and installation of waterproofing materials. The majority of the leaking basements are found in residential buildings. Old as well as new buildings are susceptible to basement leaks. An overall rise in the groundwater table in different parts of Kuwait is indicated from the field investigations. Groundwater and water used in irrigating private and public gardens are the most common sources of leakage in Kuwait's buildings. For many leaking basements, no information is available on the types of waterproofing material used for the floors and walls, suggesting a lack of importance being attached to the use of waterproofing in building basements. For the cases where information is available, fluid-applied materials are the waterproofing materials most commonly used in the basements, indicating possible poor quality materials or poor construction practices related to their installation.

INTRODUCTION

The construction of a watertight structure requires an understanding of the function of different types of waterproofing barrier systems, including such issues as when they should be used, material specifications, incompatibilities with other products, chemical resistance, correct installation procedures and construction details. In addition, the sources of moisture must be understood so that appropriate measures can be taken to prevent ingress into the structure. Factors that are often the leading causes of leakage are poor control of surface and underground water, improper selection of waterproofing material, inadequate detailing by designers, poor workmanship, inadequate supervision, and poor construction procedures (Biggins 1990). In addition, defective or poor-quality waterproofing material, as a result of an

expired product shelf-life or storage under unsuitable conditions, could considerably reduce the durability and stability of the waterproofing system.

Leaky basements are a familiar complaint in residential and commercial buildings in Kuwait. Low land elevations in Kuwait make the land susceptible to groundwater rise. A study of surface water in residential areas (Saeedy *et al.* 1987) has shown that the water table is rising in Kuwait. This water table rise appears to be man-made, resulting from excessive irrigation of private and public gardens, and leakage from sewage and water lines. The accumulation of water from these sources in a cemented or calcareous soil, such as in Kuwait (Ismael *et al.* 1986), leads to a rise in the water table. As such, measures need to be taken to protect basements, regardless of the groundwater level at the time of construction.

Relevant standards on waterproofing materials and construction are in many cases too generalized to be sufficiently useful. International documents, such as ACI 515.IR (1985), BS 8007 (1987) and CP 102 (1973), provide useful general guidelines on construction details and procedures, but are not developed to address the specific conditions related to waterproofing in Kuwait. As part of a project designed to develop a national guide for waterproofing in Kuwait, an investigation was undertaken to establish information on the local conditions regarding waterproofing materials and construction practices (Al-Mutairi *et al.* 1993 & 1995). In this paper, the procedures used to establish the relevant information are described. The data are analyzed in terms of specific parameters to determine the extent and causes of basement leaks.

FIELD INVESTIGATION OF LOCAL CONDITIONS

The field investigation consisted of three components. In the first component, information was obtained on the waterproofing materials available in the local market that are used in the construction of basements. The second component involved an investigation of local construction practices for the waterproofing of basements, while the third involved an investigation of leaking basements. The samples for field surveys on leaking basements consisted entirely of buildings with leakage problems.

Information on the waterproofing materials available in the local market was obtained by contacting local suppliers. The information was received through direct interviews and through product catalogs provided by the suppliers. Commercial and technical data for the materials were obtained.

The local practices for the application of waterproofing materials in basement construction were documented through visits to construction sites. In particular, emphasis was placed on documenting improper construction practices that could lead to leakage problems. The application of waterproofing materials requires the use of skilled manpower. Generally, such manpower is only available to large construction companies. Small private contractors usually use unskilled labor, resulting in serious mistakes being made in the installation of waterproofing materials. Even on large projects undertaken by large companies, improper installation procedures could occur in the absence of established guidelines resulting in waterproofing problems.

To obtain information on leaking basements, a field survey was designed to cover all parts of Kuwait. The country was divided into three zones consisting of nine subdivisions for all the administrative areas. Survey forms were designed requesting

the following categories of information: ownership and location of building, type of building, age of building, characteristics of relevant building components, waterproofing materials, level of groundwater, and leakage (including the time period when the leakage started, location in the building, and source). Information was obtained on a total of 151 buildings by interviewing building owners and contractors, and through direct observations. The buildings were divided into six types: residential, commercial, government, industrial, hospital, and social.

RESULTS AND DISCUSSION

The information obtained on the waterproofing materials available in the local market showed that five categories of waterproofing material are available in Kuwait. These categories are: bitumen membranes, fluid-applied materials, plastic membranes, vulcanized rubber membranes, and cementitious materials. The waterproofing materials are imported from as many as 11 countries. Thus, a broad range in the quality of the materials is to be expected. Polymer-modified bitumen membranes and fluid-applied materials are found to be the most common materials available, making up over 50 percent of all materials in the local market.

The major improper construction practices that were documented, which could damage waterproofing materials and affect the effectiveness of waterproofing systems, include: (i) overlapped areas of waterproofing membrane not properly pressed together; (ii) overheating of the membrane during welding; (iii) direct exposure of the waterproofing material to sunlight; (iv) bending of waterstops caused by improper placement that could lead to ineffective waterproofing of joints; and (v) careless dropping of steel bars, sharp objects and tools onto the waterproofing membranes that could cause puncture of the membranes. These practices are believed to contribute significantly to the high incidence of basement leakage in Kuwait.

The data for cases of actual basement leakage were analyzed in terms of key parameters to quantify the extent of the basement leakage and identify the factors associated with the causes of the leakage. The number of leaking basements was determined for each parameter, as discussed below:

Building type:

Among the six building types for which data were obtained, Fig. 1 shows that the majority of the leaking basements, about 66%, were in residential buildings. Residential, government and commercial buildings were found to have 144 of the total 151 cases of leaking basements, these buildings being located in the highly populated areas of Kuwait.

Age of the building:

Virtually all the buildings surveyed were constructed within the period from 1960 to 1990. The buildings were classified into three age groups of less than 10 years, 10 to 25 years, and greater than 25 years. The data presented in Fig. 2, show that the leaking basements are fairly distributed over all age groups. This implies that the occurrence of basement leakage in Kuwait's buildings is largely independent of the age of the building. Old as well as new buildings are susceptible to basement leaks.

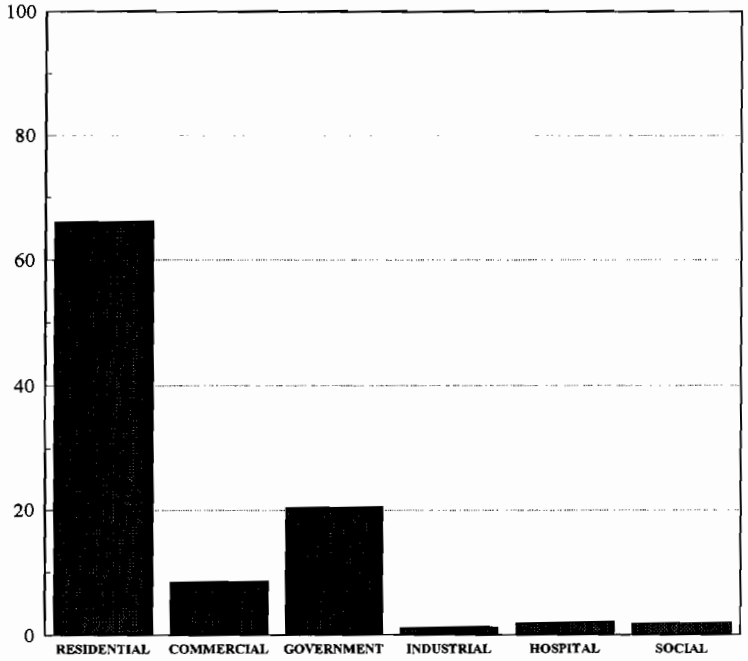

Fig. 1. Proportion of leaking basements for each building type.

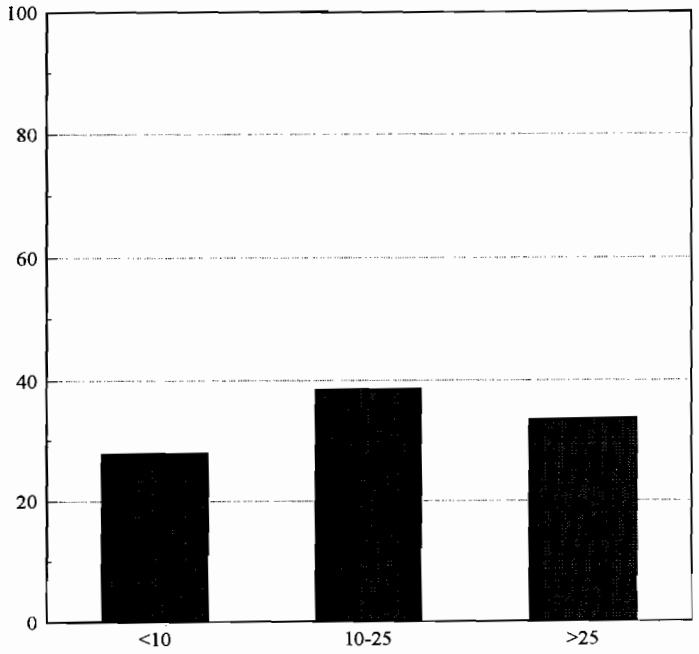

Fig. 2. Proportion of leaking basements for buildings in a given age group.

Level of water table:
Data on the current level of the water table in the vicinity of a building, as well as on the level during the period of construction of the building, were obtained in some cases. Figure 3 shows that for approximately 38 percent of these leaking basements, groundwater was encountered during the period of construction at a depth of less than 4 m from ground level. On the other hand, 70 percent of these leaking basements are currently located in areas with a groundwater level less than the 4 m depth. This indicates an overall rise in the water table as being a major cause of leakage. The floors of most of the leaking basements are located at depths within 4 m from ground level. As such, a rise in the water table to within this depth would increase the number of leaking basements.

The proportion of basements for which groundwater was encountered during the period of construction is compared in Fig. 4 with the proportion of leaking basements for residential, commercial and governmental buildings. These proportions were calculated based on 118 of the 151 surveyed buildings for which the ground conditions during the period of construction were known. For residential and governmental buildings, the proportion of leaking basements is approximately three times greater than the proportion of basements for which groundwater was encountered during the period of construction. This points to a rise in the water table following the period of construction, in addition to other possible sources contributing to basement leakage.

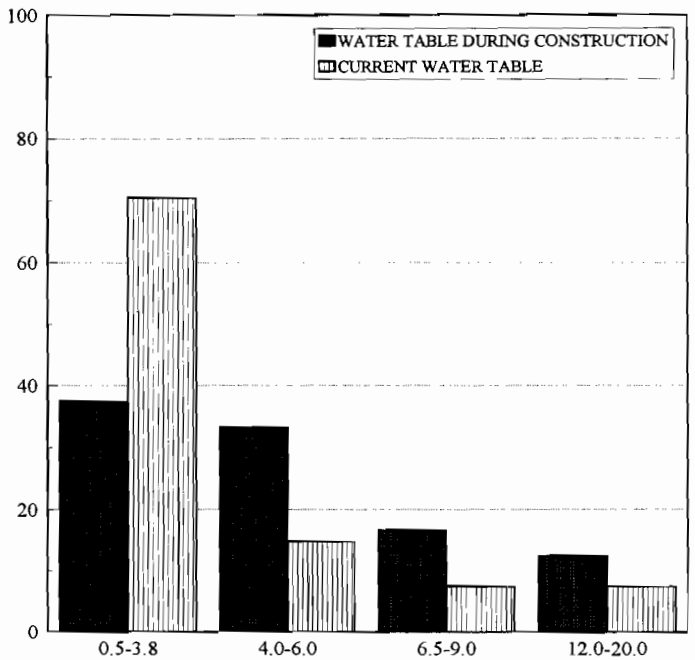

Fig. 3. Proportion of leaking basements with respect to the level of water table.

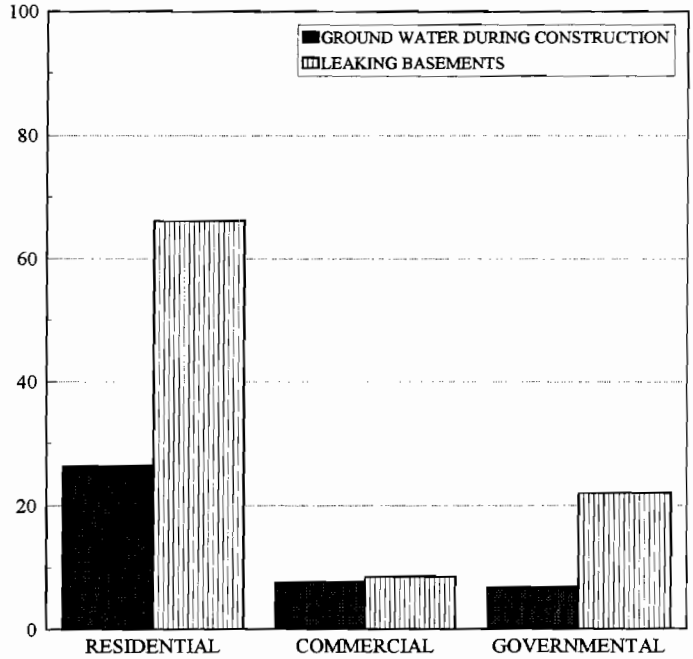

Fig. 4. Proportion of leaking basements with respect to the presence of groundwater during the period of construction.

Leak source:
Six sources of leakage (groundwater, irrigation water, water supply, rain, seawater and sewage) were identified. Groundwater and irrigation water were found to be the most common sources of leakage in residential buildings, making up approximately 45% of all occurrences, as shown in Table 1. For government buildings, the most common source of leakage was water used in irrigating nearby gardens.

Type of waterproofing material:
The proportion of leaking basements for which information on the type of waterproofing material used for floors and walls was obtained, is presented in Fig. 5 (for residential, commercial, and government buildings). The figure shows that this infor-

Table 1. Frequency of leak source for all building types.

	Relative frequency of leak source (%)					
Leak source	Residential	Commercial	Governmental	Industrial	Hospital	Social
Groundwater	26.6	4.0	4.0	0.9	1.0	0.4
Irrigation	18.0	0.5	11.3	—	1.0	—
Water Supply	7.2	1.0	0.9	—	—	—
Rain Water	7.2	0.4	7.7	—	0.5	0.4
Sea Water	0.4	1.8	—	—	—	—
Sewage	4.0	—	0.4	0.4	—	—

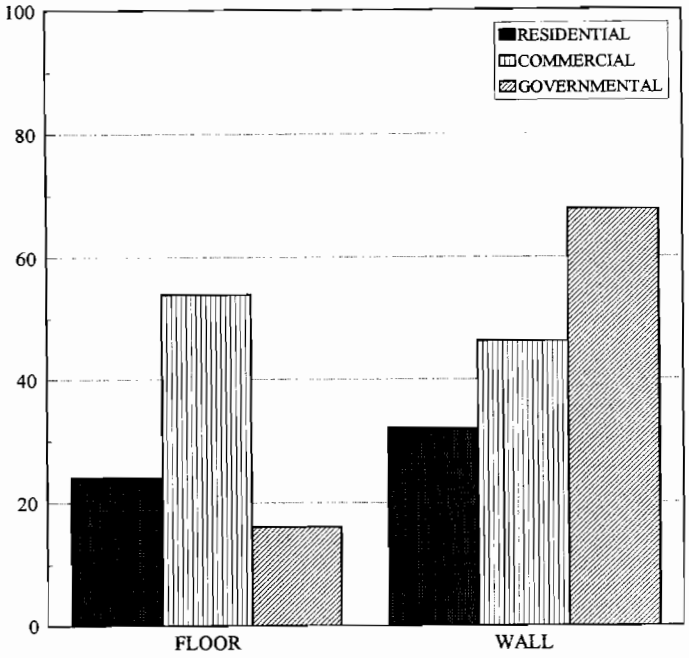

Fig. 5. Proportion of leaking basements with known types of waterproofing material.

mation was available in only some cases. For leaking basements in residential buildings, Fig. 5 shows that information was available on the type of waterproofing material used for the floors in only 24 percent of the cases. The corresponding value for the walls is 32 percent. These low values suggest a lack of importance being attached to the use of waterproofing in building basements.

Table 2a. Proportion of leaking basements by type of floor waterproofing material.

Floor waterproofing material	Proportion of leaking basements (%)		
	Residential	Commercial	Governmental
Cold fluid applied	24.3	8.1	8.1
Hot fluid applied	16.2	2.7	2.7
Bituminous membrane	16.2	8.1	2.7
Cementitious material	8.1	—	—

Table 2b. Proportion of leaking basements by type of wall waterproofing material.

Wall waterproofing material	Proportion of leaking basements (%)		
	Residential	Commercial	Governmental
Cold-fluid applied	20.0	3.3	33.3
Hot-fluid applied	18.3	1.7	—
Bituminous membrane	11.7	5.0	1.7
Cementitious material	3.3	—	—

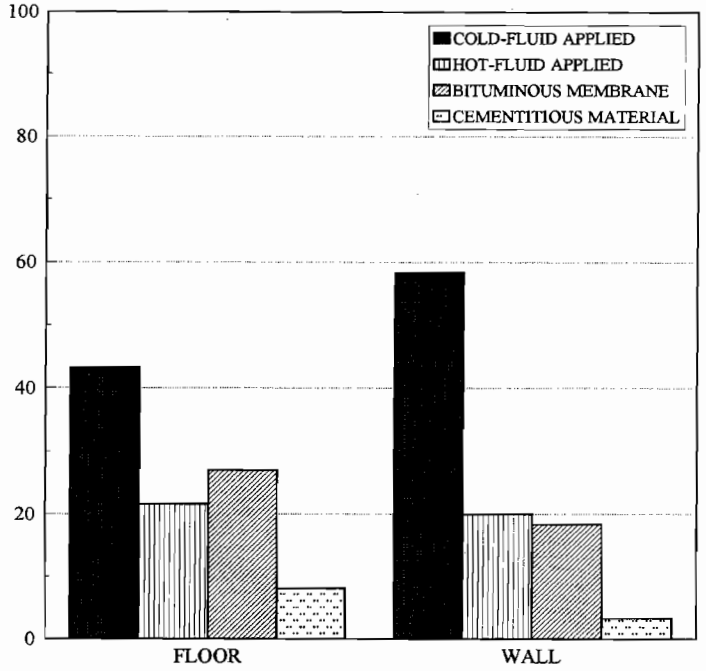

Fig. 6. Proportion of leaking basements for particular types of waterproofing material.

In the few cases for which information was available, Tables 2a and 2b show the proportion of leaking basements in residential, commercial and governmental buildings for each of four types of waterproofing material. Figure 6 shows that cold-fluid applied bitumen, hot-fluid applied bitumen, and bituminous membrane are the most common types of waterproofing material used for the floors and walls in the buildings. Fluid applied bitumen materials are the waterproofing materials used in approximately 60 to 80 percent of the cases of leaking basements. This suggests either poor quality materials or poor construction practices related to their installation.

CONCLUSIONS

The following conclusions summarize the findings of the study:

1. Waterproofing materials from as many as eleven countries are available in Kuwait for the construction of building basements. Thus, a broad range in the quality of the materials is to be expected. To ensure adequate performance of waterproofing systems, the materials should be carefully selected for specific applications.
2. A number of improper construction practices with respect to waterproofing have been identified, pointing out the need for improvements in the handling and installation of waterproofing materials.
3. The majority of leaking basements occur in residential buildings.

4. The leaking basements are evenly distributed over all age groups; old as well as new buildings are susceptible to basement leaks.
5. Groundwater and water used in irrigating private and public gardens are the most common sources of leakage in the basements.
6. In cases where information was available on waterproofing material type, fluid applied bitumen materials are found to be the waterproofing materials most commonly used for the floors and walls of the leaking basements. This suggests possible poor quality materials or poor construction practices related to their installation.

ACKNOWLEDGEMENTS

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تسرب المياه الى سراديب المباني في الكويت
المدى والأسباب

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خلاصة

تنتشر ظاهرة تسرب ورشح المياه في السراديب بشكل واسع في دولة الكويت ويعزى السبب الرئيسي في هذه المشكلة الى زيادة ارتفاع مناسيب المياه الجوفية نتيجة للافراط في عمليات ري المزروعات والحدائق المنزلية، ونتيجة للتسرب من أنابيب المياه والصرف الصحي. هذا بالاضافة الى الافتقار الى الاهتمام بنوعية المواد العازلة للمياه والطريقة الملائمة للاستخدام وذلك أثناء بناء وتشييد المباني والسراديب في الكويت. وسعيا وراء تطوير دليل ارشادي وافي للمواد العازلة والمانعة لتسرب المياه في سراديب المباني تم اجراء دراسة استقصائية لجمع المعلومات والبيانات حول المواد العازلة والمانعة للتسرب المتوفرة محليا وكذلك حول ممارسات البناء والتشييد المتبعة.

عند جمع وحصر المواد العازلة والمانعة للتسرب المتوفرة في الأسواق المحلية، وجد أنه يتم استيرادها من احدى عشر دولة مما يشير الى تفاوت كبير من حيث جودة ونوعية هذه المواد باختلاف مصادرها. كما تم أيضا تحديد ورصد العديد من ممارسات البناء غير السليمة عند التعامل مع هذه المواد وتركيبها، وقد وجد أن أغلب حالات التسرب والرشح كانت في سراديب المباني السكنية والمنازل سواء في ذلك الجديدة منها أو القديمة. وقد بين المسح الميداني أن هناك ارتفاع عام في مناسيب المياه الجوفية في أجزاء متفرقة ومختلفة من مناطق الكويت. وقد وجد أن المياه الجوفية، والمياه المستخدمة لري الحدائق والمزروعات في الحدائق العامة والخاصة هي المصادر الرئيسية لرشح المياه في المباني السكنية في الكويت. وبالنسبة للعديد من سراديب المباني التي تعاني من مشاكل تسرب ورشح المياه، لم تتوفر لدى أصحابها للأسف معلومات كافية حول أنواع مواد العزل ومنع التسرب المستخدمة في أرضيات وجدران منازلهم. مما يشير الى عدم الاهتمام باستخدام مواد عزل ومنع تسرب جيدة في سراديب المباني لمنع حدوث هذه الظاهرة. وبالنسبة للحالات التي توفرت لديها معلومات فقد وجد أن مواد العزل السائلة هي الأكثر شيوعا واستخداما في عزل السراديب مما يشير الى احتمال رداءة النوعية المستخدمة أو قلة خبرة العمالة في استخدام هذه المواد وتركيبها.