ITU A|Z
VOL: 9, NO:1, 134-148, 2012-1

Durability of external thermal insulation composite systems in Istanbul Turkey

Ecem EDİS, Nil TÜRKERİ [1]
Istanbul Technical University Faculty of Architecture, Istanbul TURKEY

Received: October 2011 Final Acceptance: February 2012

Abstract:
External Thermal Insulation Composite Systems (ETICS) have entered the Turkish market in late 1990s. However, there is no information regarding their durability. This study presents the field inspection results conducted to assess the durability of extruded polystyrene (XPS) based ETICS, when exposed to degradation agents originating from atmosphere, occupancy, design, and construction in Istanbul, Turkey. Initially, the exposure environment of Istanbul was determined. Subsequently, a survey form was prepared to be filled out by ETICS suppliers and contractors to determine the location of buildings with ETICS in Istanbul and to obtain data regarding ETICS installation. Data describing the state of the building facades with ETICS was gathered through field inspection. Observed defects were classified according to the origin of the degradation agents, i.e. external and internal degradation agents and the presence, type and intensity of the defects. Results of field inspection of the 44 buildings with XPS based ETICS indicated that when exposed to external degradation agents of Istanbul, the state of the facades having an exposure life of 1 to 7 years proved to be virtually without defects. However, when the effects of internal degradation agents, i.e. improper use of occupants, improper design and defective construction are considered, a quite number of defects such as delamination, drill holes were observed at the facades.

Keywords: *Durability, degradation, defect, external thermal insulation composite systems, field inspection.*

1. Introduction

Building construction sector is one of the major constituents of Turkish economy. According to the latest study conducted by Turkish State Institute of Statistics, there are about 6.6 million residential buildings in Turkey, ~11% of which are located in Istanbul (State Institute of Statistics, 2000). The buildings in use consume 34.5 % of the total energy of the nation, and 80% of this energy is consumed for heating. Therefore, the energy used in the operation of buildings is one the main issues of the sustainable building strategy of Turkey in order to conserve energy and sustain societal well being. A policy has been developed in governmental level to promote energy efficiency and a standard titled "TS 825 - Conservation Rules of Heat Effects for Buildings" was activated in 1970 to insulate the new buildings and to retrofit the existing building stock. This standard has been revised in the years of 1979, 1985 and 1998 in terms of decreasing the U values of the building envelope. A regulation regarding thermal insulation of buildings was also enforced in 2000 aiming the promotion of energy efficiency in Turkey. Recently a new revised standard TS 825: 2009 Thermal Insulation Requirements for Buildings was ratified. In accordance with the new standard, the existing regulation was revised as well. Subsequent to the implementation of the TS 825:1998 standard, external thermal insulation composite systems (ETICS) have entered to the Turkish construction market and their market shares have been significantly increasing since the given date.

Even though the government issued policies to promote energy efficiency since 1985, correct design and proper installation of the system by the designers and contractors required some time. Partial application of external thermal insulation system at a building; only onto facade(s) where highest heat loss occurred, and omitting some components such as mechanical fasteners, rendering mesh required for proper installation were among the common examples seen during the initial periods of the system application as demonstrated in Figure 1. The building in Figure1 has been built in 1996 in Istanbul, Turkey, when the TS 825:1985 standard was in force, but there was no thermal insulation at the exterior walls. Subsequent to the implementation of the TS 825:1998, interestingly, only an extension of the facade has been insulated, and the remaining parts left thermally uninsulated. No defects were observed at the thermally insulated part of the facade during the inspection performed at winter 2008, but the shapes of the mechanical fasteners were clearly visible. As stated by the facility manager, mechanical fasteners have not been used at the initial installation and after some time, some of the thermal insulation boards have been detached from the substrate. These detached boards has been replaced with new boards and covered with new base and finish coats. Additionally, mechanical fasteners have been applied onto the new and existing finish coats and then the facade has been painted. Therefore, the shapes of the mechanical fasteners were visible during the inspection.

A comprehensive literature review analyzing the implementation and use of ETICS revealed that commercial and technical development of modern ETICS occurred primarily in the post-World War II Germany. In the North America, ETICS became widely available after the oil crisis of the early 1970s and in Turkey after the implementation of TS 825: 1998 standard. In-situ performance investigation of substantial numbers of multi-storey buildings with ETICS has been started as early as 1975 in Germany and in the early 1990s in the North America. Results of these inspections concluded that even ETICS which were in good condition were not entirely free of defects and failures. The vast majority of these defects and failures had derived, almost without exception, from either faulty detailing or faulty installation. Hence it had been concluded that the durability of ETICS was dependant on the workmanship quality during the construction and subsequent maintenance processes (CMHC, 1991; CMHC, 1993; Crandell et al; 1996; Brown et al, 1997; Williams et al, 1998). In spite of several investigations dating back to the year of 1975 in the countries where ETICS are widely used, presently there is no research regarding the long-term performance of ETICS in the conditions of Turkey, especially in terms of their durability, apart from other performance requirements such as indoor environmental comfort.

Figure 1. *An example to the thermal insulation applications carried out during the initial periods of becoming a common practice – the left hand side of the facade is thermally uninsulated and the other part is insulated*

Extruded polystyrene (XPS) and expanded polystyrene (EPS) are the two materials that have been widely used in Turkey in the ETICS applications. The use of rock wool or glass wool is limited but increasing lately. Considering that there is no research regarding the performance of ETICS in the conditions of Turkey, a research was conducted based on in-situ visual inspections and focusing on the durability of XPS based ETICS when exposed to degrading agents originating from atmosphere, occupancy, design and construction conditions in Istanbul, Turkey. This study presents the methodology and results of the aforementioned field inspections aiming to contribute to the appropriate application and maintenance of XPS based ETICS in Turkey.

2. Methodology

The ISO 6241:1984 standard (ISO, 1984) indicates that performance of a building component, covering the durability performance as well, can be assessed when exposure environment, exposure time, building use and the state of the components are established. In this study, initially, the data on the exposure environment of Istanbul, and the data on inspected buildings comprising building use, exposure time and description of the ETICS assembly were gathered. The data regarding the state of the facades with ETICS were then gathered through in-situ inspections. Following subsections provide information on the methods used to obtain the data and the method conducted to assess the durability of ETICS.

2.1. Exposure environment

Durability of a building component is mostly yielded by complicated chemical and/or physical processes governed by a great number of degradation agents. The ISO 6241:1984 standard classifies these agents according to their nature as (i) internal and (ii) external to the building. In general, external to the building the origin of the agents is either the atmosphere or the ground, whereas internal to the building the origin is related to occupancy or design and installations. Furthermore, degradation agents are grouped under the headings of mechanical, electromagnetic, thermal, chemical and biological agents according to their nature. The origin of the most relevant agents affecting the durability of building's external components is usually the atmosphere. These are freeze-thaw, temperature and moisture differences and wind under mechanical agents; solar radiation under electromagnetic agents; temperature under thermal agents; and precipitation, humidity, normal air constituents and air contaminants under chemical agents.

In order to describe the exposure environment of Istanbul and to provide some quantitative information on agents originating from the atmosphere, the following data were determined: (i) annual maximum, mean and minimum air temperatures (°C); (ii) annual maximum, mean and minimum relative humidity values (%); (iii) annual solar radiation sum on a vertical surface namely on an external wall surface (kWh/m2); and (iv) annual driving rain sum on a vertical surface (mm). Values of air temperature (°C) and relative humidity (%) were obtained from Turkish State Meteorological Service. Annual solar radiation sum on an external wall surface (kWh/m2) and annual driving rain sum on a vertical surface (mm) were derived from calculations conducted with WUFI 4, a pc software allowing the calculation of the transient heat and moisture transport in building elements when exposed to climatic conditions of a particular location (Künzel, 1995).

As agents related to occupancy, design and installation can affect the durability of building components, these were also considered in the study. Information relevant to the given agents was obtained from facility managers of the buildings.

2.2. Data collection on buildings with ETICS

Initially, a survey form was prepared and thereafter sent to particularly XPS based ETICS suppliers and contractors to determine the locations of buildings in Istanbul that have been thermally insulated with ETICS and to obtain data regarding ETICS installation. Table 1 presents the format of the survey form used in the collection of building information. Based on the results of the survey, an inventory of the building stock was prepared. The survey also provided data about the buildings, i.e. building use, historical data - date of construction of the building, date of ETICS installation, performed maintenance date(s), and description of the components of the ETICS assembly and the substrate. Specifically, historical data provided information regarding the exposure time of the components under the given exposure environment. Subsequently, buildings were visited and permissions from facility managers and/or property owners were sought to conduct field inspections for the assessment of the long-term performance of these buildings' ETICS applications.

Table 1. *Format of the survey form used in the collection of building information*

Building site and number of inspected buildings	Historical data (exposure time)			Components of the ETICS assembly and substrate				
	Building construction date	ETICS installation date	Maintenance date (s)	Finish coat	Base coat and mesh	Thickness of thermal insulation (cm)	Adhesive/ mechanical fastening	Substrate

2.3. Durability assessment

Data describing the state of the building facades, which have been thermally insulated with ETICS, were gathered through field inspections conducted during fall and winter seasons of 2008. Field inspection of a building was conducted as the following. Initially, the orientation of each facade was determined to define the facades exposed to highest solar radiation and driving rain loads as agents external to the building. At each facade of the building, ground floor areas were carefully examined by naked eye and upper floor areas with binoculars. The state of each facade was recorded with a general photograph. Additionally, photographs of each defect, if any, at the inspected facade were taken. The location of the defect(s) was also marked on the general photograph of the facade. The aforementioned methodological manner was conducted for each facade of the building and eventually for the whole building stock.

In order to describe the state of the facades, the first attempt was made to classify them according to the presence, type and intensity of the defects. However, at the duration of field inspection of the buildings with ETICS, it became apparent that the defects should also be classified according to the origin of the degradation agents; i.e. defects due to external and internal degradation agents. Hence, for the study, initially, defects are classified according to the origin of the degradation agents and then the presence, type and intensity of the defects. The following describes the assessment groups. Assessment group 1 covers the defects that may have occurred due to the external degradation agents (originating from the atmosphere). The state of the facades is further classified according to the presence and type of the defects, and their intensity. For the study, the sub classification which has previously been offered at a similar study conducted by Künzel et al (2006) was used. Künzel et al (2006) offered three condition levels for the classification of the state of the facades, as the following: (i) virtually without defects - no visible defects or small groove cracks hardly visible at a normal distance, (ii) minor defects - few cracks, e.g. starting at window corners, longer groove cracks or isolated cracks along insulation board joints, hardly noticeable, only visible at closer examination, (iii) major defects - frequent or longer cracks, for the most part along insulation boards joints and/or blistering or delamination of coatings, clearly visible.

Assessment group 2 covers the defects that have occurred due to internal degradation agents; i.e. occupancy, design and construction. State of the facades in terms of these defects was classified as either “with defects” or “without defects”. Reliable information related to the causes of these defects was obtained from the facility managers.

3. Results

3.1. Exposure environment

Istanbul is located at a temperate climate region. Its longitude is 28.95° East and its latitude is 41.03° North. According to the data obtained from Turkish

State Meteorological Service, the annual mean, maximum and minimum temperatures experienced in Istanbul are 14.3, 31.5 and -3.5 °C, respectively. The annual mean, maximum and minimum relative humidity values in Istanbul are 76, 100 and 41 %, respectively. Table 2 presents the values of annual sun radiation sum on a vertical surface (kWh/m2) and annual driving rain sum (mm) according to eight cardinal directions. Observation of Table 2 reveals that SW and W facades of buildings in Istanbul are exposed to the highest amount of solar radiation; while NW facades of buildings are exposed to the highest value of driving rain.

Table 2. *Values of sun radiation sum on a vertical surface (kWh/m^{2}a) and driving rain sum (mm/a) according to eight cardinal directions*

Orientation	Sun radiation sum - kWh/m^{2}a	Driving rain sum - mm/a
N	389	140
NE	327	80
E	338	105
SE	384	140
S	619	120
SW	1078	120
W	1170	170
NW	810	200

3.2. Buildings with ETICS

Figure 2 displays the locations of the building sites, which have been investigated. Briefly, nine building sites and 44 buildings were inspected during this study. All of the inspected buildings were residential buildings. Regarding ETICS, mineral based finish and base coats with fiberglass mesh were commonly applied on either 3 or 4-cm thick extruded polystyrene (XPS) thermal insulation boards, which had been adhered and mechanically fastened to brick/block infill walls or reinforced concrete structural members as the substrates.

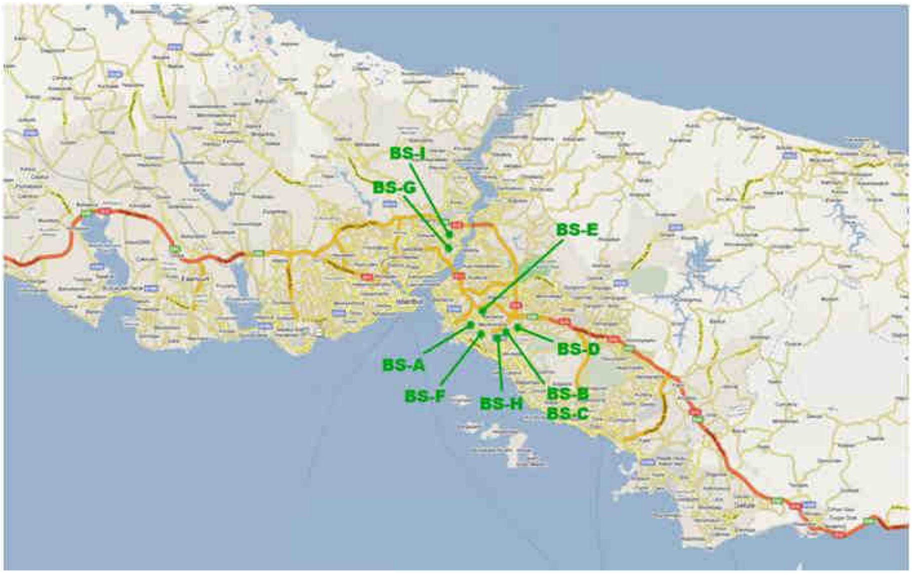

Figure 2. *Location of inspected buildings with ETICS in Istanbul*

3.3. Durability assessment of buildings with XPS based ETICS

Classification of the state of the facades of 44 buildings with XPS based ETICS according to the assessment groups are provided in Table 3. Additionally, construction dates of the inspected buildings, installation dates of XPS based ETICS, maintenance dates, if any, and the exposure time of ETICS are provided at the same table.

Code of building site/ Number of buildings at the site	Age of ETICS (years)	Date (year)															Assessment groups	
		1991	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008 - date of inspection	Group 1 due to external agents	Group 2 due to internal agents
BS-A/5	1														C	E	Virtually without defects	With defects *Delamination Exposure of components*
BS- B/4	2			C										E			Virtually without defects	Without defects
BS- C/1	4	C										E					Virtually without defects	With defects *Exposure of thermal insulation*
BS-D / 2	5										C E					M	Virtually without defects	Without defects
BS-E/ 3	5						C				E						Virtually without defects	With defects *Drill holes*
BS-F/ 2	5										C E						Virtually without defects	With defects Delamination
BS-G/ 3	7	C							E								Virtually without defects	With defects *Exposure of thermal insulation, drill holes, etc.*
BS-H/ 1	7								C E								Virtually without defects	Without defects
BS-I/ 23	12			C E					M				M				Minor defects Mainly small cracks	Without defects

C: Construction date of building/s; E: Installation date of ETICS; M: Date of maintenance

In building site A (BS-A), there are eight-storey high five residential buildings, which have been built in the year of 2007 and have been retrofitted with ETICS in the year of 2008. No defects originating from the external degradation agents were observed at all inspected facades of these buildings, hence all of these five buildings were classified as "virtually without defects" under assessment group 1. However defects resulted from internal degradation agents – i.e. assessment group 2 – were observed at most of the facades. In terms of these types of defects, Figures 3a and 3b demonstrate examples at a wall-pipe interface and a wall-closet interface, respectively. A closer examination of the wall-pipe interface revealed the fiberglass mesh while whole components of the ETICS could be observed at the wall-closet interface. It is considered that the interfaces have been imperfectly designed and the penetrations have been defectively installed. Additionally, Figure 3c illustrates delamination due to impact loads at ETICS at the ground floor level of building at BS-A.

In BS-B, four of the several buildings, which are nine to ten-storey high, have been thermally insulated with XPS based ETICS in the year of 2006, nine years after the initial construction. Limited numbers of isolated cracks such as small groove cracks that are hardly visible with binoculars were observed during inspection. Therefore, the facades of these buildings were classified as 'virtually without defects' and "without defects" under the assessment groups 1 and 2, respectively.

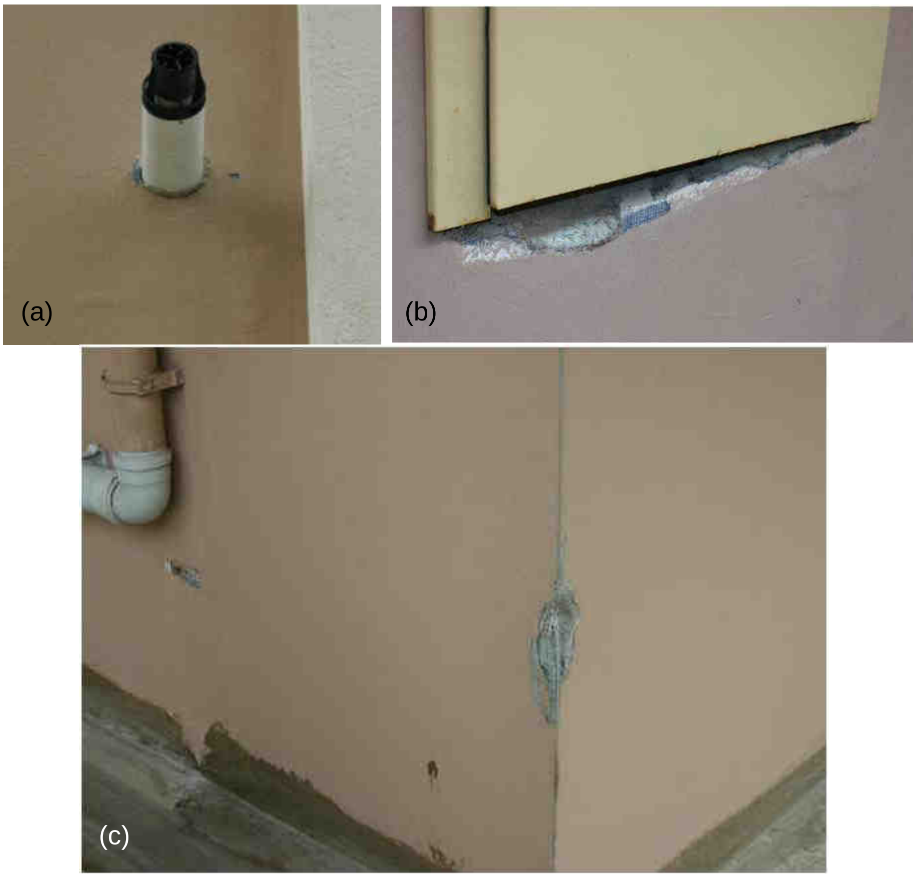

Figure 3. *Examples of the defects observed at BS-A: (a) delamination at wall-pipe interface, (b) wear off at wall-closet interface, (c) delamination due to impact load.*

In BS-C, buildings have been constructed in the year of 1991; only one building has been thermally insulated with XPS based ETICS in the year of 2004 and no maintenance work has been carried out since the given date. No defects due to external degradation agents were observed during the inspections and hence, all the facades of the building were classified as 'virtually without defects'. However, it was observed that during the renewal of window frames and sills by the owner of the apartments, some parts of the thermal insulation boards have been left exposed to the environment due to improper construction work (Figure 4), and hence the facades were classified as 'with defects' under the assessment group 2.

Figure 4. *Exposure of thermal insulation material due to renewal of window frame and sill at BS-C*

In BS-D, ten-storey high two buildings have been constructed and thermally insulated in the year of 2003, and maintenance work has been carried out during the summer months of 2008, i.e. 2-3 months prior to the field inspection. Therefore, no defects due to external and internal degradation agents were observed, hence all the facades were classified as "virtually without defects' and "without defects" under the assessment groups 1 and 2, respectively.

In BS-E, there are eight-storey high three buildings, which have been constructed in the year of 1999. ETICS have been installed in the year of 2003 and no maintenance has been carried out since then. During the inspection, only a single isolated defect due to external degradation agents, i.e. a crack at the interface of reinforced concrete beam and brick infill (Figure 5a), was observed at one facade and therefore all the facades were classified as 'virtually without defects'. On the other hand, use related defects such as drill holes that have not been repaired after the removal of mounted items like lighting fixtures, security cameras, etc. were observed at several facades (Figure 5b), and hence the facades were classified as 'with defects' under the assessment group 2.

BS-F stationed 15-storey high two buildings, which have been constructed in the year of 2003 with ETICS. Apart from 1-2 isolated cracks at window corners (Figure 6a), there were no defects due to external agents and hence all facades were classified as 'virtually without defects'. In terms of internal degradation agents, delamination problems caused by the impact of falling tiles from the upper portion of the walls and during the replacement of the missing tiles, were observed as explained by the facility manager of the buildings, and therefore the facades were classified as 'with defects' (Figure 6b).

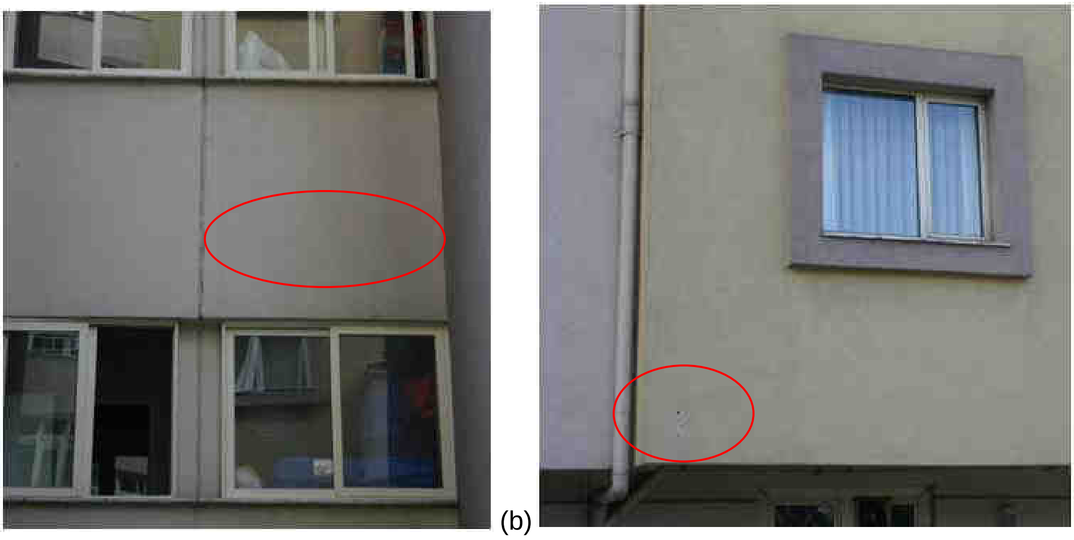
(a) (b)

Figure 5. *Examples from BS-E: (a) crack at floor beam-infill wall interface, (b) drill hole that has not been repaired after the removal of a security camera*

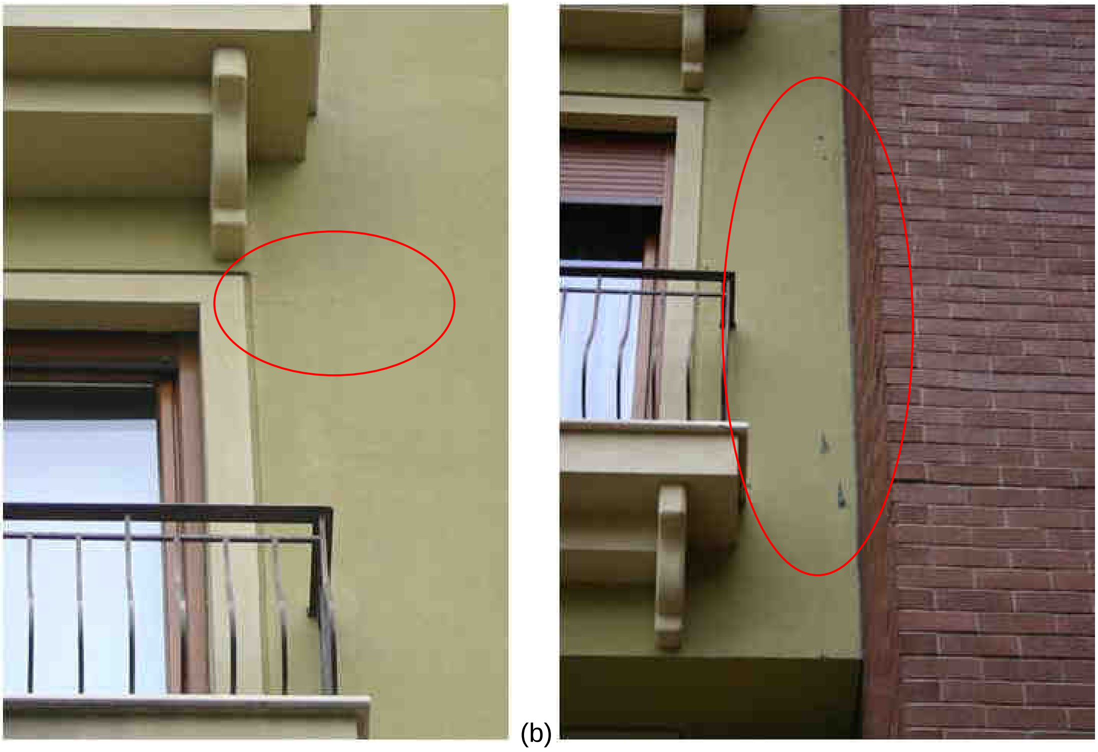
(a) (b)

Figure 6. *Examples from BS-F: (a) isolated crack at window corner, (b) delamination problems that have been occurred due to the impact of falling tiles*

In BS-G, three buildings of five to six-storey high have been built in the year of 1991 and have been thermally insulated with XPS based ETICS in the year of 2001. No maintenance work has been carried out since the given date. No defects due to external environmental agents were observed during the inspection and all facades were classified as 'virtually without defects'. In terms of internal degradation agents, several defects such as delamination due to defectively installation of an air-conditioning unit, drill holes etc were observed. Figure 7 presents an example of these types of defects; i.e. wearing off the finish coat and exposure of thermal insulation material to the atmosphere at the window sill due to improper detailing and construction.

Figure 7. *Exposure of thermal insulation material to the atmosphere due to wearing off the finish coat at BS-G*

In BS-H, there is one building, which is 12-storey high. The building has been constructed in the year of 2001 with XPS based ETICS, and no maintenance has been carried out. Only at the north facing facade of the building, a few number of small groove cracks hardly visible at a normal distance were observed and hence all facades of the building were classified as 'virtually without defects'. No defects due to the effects of internal degradation agents were observed at the facades of BS-H.

BS-I comprised five to six storey-high 23 buildings. XPS based ETICS have been installed during the initial construction and regular maintenance work has been carried out at every 4 to 5 years. During the inspection, longer groove cracks were observed at most of the facades of 23 buildings in terms of the effect of external degradation agents. Therefore the facades were classified as 'minor defects' under the assessment group 1. An example facade with this type of defect is provided in Figure 8. In terms of internal degradation agents, 23 buildings were observed to be defect free.

4. Conclusion

Field inspections conducted to investigate the long term performance of ETICS in Istanbul covered 44 buildings located in different regions of Istanbul. In these ETICS applications, mineral based finish and base coats with fiberglass mesh were applied onto 3 or 4-cm thick XPS thermal insulation boards, and the exposure times of ETICS, as given in Table 3, ranged from 1 to 12 years.

Figure 8. *Example to the cracks observed in most buildings at BS-I*

When exposed to external degradation agents of Istanbul, it is observed that, the state of the facades of the buildings with ETICS having an exposure life of 1 to 7 years proved to be "virtually without defects', even when facing directions of increased solar exposure and wind-driven rain load. However, the state of the facades of the buildings with ETICS having an exposure life of 12 years bared 'minor defects'. No apparent relation was observed among the intensity of the defects observed and the orientations of the facades that define the severity of exposure conditions, which cover the condition of being protected by other buildings as well. Investigations carried out on the interior surfaces of the facades with minor defects revealed that these defects had not caused any visible defects at the interior surfaces of the walls or had not decreased the thermal comfort of the interior space as expressed by the users. This suggests that such defects do not have any influence on the moisture or thermal performance of the XPS based ETICS when exposed to the external degradation agents of Istanbul for a maximum of 12 years. It is observed that maintenance of ETICS was not a common practice in buildings with ETICS as well.

When the effects of internal degradation agents, i.e. improper use of occupants, improper design and deficient construction are considered, a quite number of defects were observed at the facades. Delaminations due to impacts, faulty penetration of service system components and/or penetration/drill holes left untreated after the removal of items mounted onto the facade surface were the examples observed in relation with the improper use of occupants. Lack of specific mesh at the locations susceptible to increased loads such as the corners around windows and inattentive construction operations during the renewal of other facade components such as window frames or other facade claddings were the examples observed in relation with improper design and deficient construction. These types of defects increase the risk of vulnerability of the components in the assembly to premature deterioration and thus adversely affect the long-term performance of the assembly. This suggests that architects, contractors and users should be educated for appropriate detailing, construction and use of building elements with ETICS, respectively. Facility managers should be informed as well to conduct regular maintenance work in order to repair these types of defects.

The study presented here covered only the buildings with XPS based ETICS. As future work, a similar study, covering field inspections of buildings with EPS based ETICS to evaluate their durability in Istanbul, Turkey and to perform a comparative assessment of the durability of XPS and EPS based ETICS is planned.

Acknowledgement
Authors would like to express their special thanks to ETICS suppliers, contractors and facility managers of the inspected buildings for the information they have provided to the study.

[1] Corresponding author

References

Brown, W., Ullett, J., Karagiozis A., (1997), Barrier EIFS clad walls: results from moisture engineering study, **Journal of Thermal Insulation and Building Envelopes**, Vol. 20, 206-226.

CMHC, (1991), **EIFS problems, causes and solutions**, Canada: Canadian Housing and Mortgage Corporation.

CMHC, (1993), **Exterior insulated finish systems (EIFS) field performance evaluation**, Canada: Canadian Housing and Mortgage Corporation.

Crandell, J., Kenney, T. (1996), **Investigation of moisture damage in single-family detached houses sided with exterior insulation finish system in Wilmington***, NC*. Upper Marlboro, MD: NAHB Research Center, Inc.

ISO 6241 (1984), Performance standards in buildings – principles for their preparation and factors to be considered**, International Organization for Standardization**, Geneva.

Künzel, H.M., (1995), **Simultaneous heat and moisture transport in building components.-One- and two-dimensional calculation using simple parameters**. Germany: IRB Verlag.

Künzel, H., Künzel, H. M., Sedlbauer, K., (2006), Long-term performance of external thermal insulation systems (ETICS*),* **Architectura**, Vol. 5, No.1, 11–24.

State Institute of Statistics, (2000), **Building census 2000**, Ankara: Turkish State Institute of Statistics.

Williams, M.F., Williams, B.L., (1998), An overview of water leakage problems in single family residences clad with exterior insulation finish system (EIFS). In Kudder and Erdly (Eds.), **ASTM Special Technical Publication no. 1314: Water leakage through building facades***,* American Society for Testing and Materials, West Conshohocken, USA.

Günümüzde binalardaki enerji korunumu önemli oranda ısıtma enerjisi korunumu ile sağlanmaktadır. Ülkemizde de, binalarda ısı kayıplarının azaltılması ve yakıt tasarrufu sağlanmasına yönelik ilk çalışma TSE tarafından Şubat 1970 tarihinde TS 825-Binalarda Isı Etkilerinden Korunma Kuralları adı altında yayınlanmış ve Haziran 1979 ile Nisan 1985 tarihlerinde revize edilmiştir. Türkiye'deki binalarda birim alanı veya hacmi ısıtmak için harcanan enerjinin Avrupa ülkelerindekilere göre 2-3 kat daha fazla olması nedeniyle 1985 tarihli ‘Binalarda Isı Yalıtımı Kuralları’nı belirleyen TS 825 Standardı da revize edilmiş ve yeni standart, Haziran 2000 tarihinden itibaren zorunlu uygulamaya girmiştir. 1985 tarihli Bayındırlık ve İskan Bakanlığı ‘Binalarda Isı Yalıtımı Yönetmeliği’ de Haziran 2000 tarihli yeni standartla paralellik sağlayacak şekilde revize edilerek Haziran 2000'den itibaren yürürlüğe girmiştir. Günümüzde binalarda ısıtma enerjisi korunumu, Haziran 2000 tarihli standardın öngördüğü ısıl geçirgenlik katsayısını sağlayan, doğru malzemeler ve doğru katmanlaşma modeliyle tasarlanmış, doğru uygulanarak gerekli bakım ve onarımı yapılan ısı yalıtımlı bir bina kabuğu ile sağlanabilmektedir.

İstanbul’da 2002 yılında yürütülen bir çalışma, Haziran 2000 tarihli standart ve yönetmeliğin geçerli olduğu dönemden önce inşa edilen binalarda, toplama malzemelerle oluşturulan sıva kaplamalı ısı yalıtımlı dış duvar sistemlerinin kullanıldığını, bu uygulamalarda yanlış tasarım ve hatalı yapımdan kaynaklanan çok çeşitli hasarların oluştuğunu, toplama ısı yalıtım sisteminin dış duvardan ısı kayıplarını azaltma işlevini yerine getiremediğini ve sonuç olarak bu sistemin gerçek hizmet şartları altında uzun dönem performansının yetersiz kaldığını ortaya koymuştur. Toplama sistemde oluşan hasarlar nedeniyle, 1990’ların sonundan itibaren, Haziran 2000’de yürürlüğe giren standart ve yönetmelik ile birlikte artan oranda, başta İstanbul olmak üzere tüm Türkiye’de, ‘paket dış cephe ısı yalıtım sistemleri’ ağırlıklı olarak konut binaları olmak üzere binalarda uygulanmaya başlamıştır. Paket sistem; ‘sisteme özel bileşenleri ilgili ulusal standartlarda verilen yöntemlere göre test edilerek üretilen, katmanlaşması benzer şekilde tasarlanarak eğitimli işçiler tarafından uygulanan ve kullanım sürecinde bir bütün olarak performans gösteren kompozit bir sistem’ olarak tarif edilmektedir. Ancak, paket sistemin ülkemizdeki gerçek hizmet şartları altında dayanıklılığını ortaya koyan bir çalışma bulunmamaktadır. Bu çalışma, Istanbul’daki mevcut binalarda uygulanmış olan haddelenmiş polistren (XPS) ısı yalıtım malzemesi esaslı paket dış cephe ısı yalıtım sistemlerinin gerçek hizmet şartları altında dayanıklılığını değerlendirmek amacıyla gerçekleştirilmiştir.

ISO 6241: 1984 standardında bir yapı elemanın dayanıklılığının değerlendirilmesi için; yapı elemanının maruz kaldığı çevresel etmenlerin, çevresel etmenlere maruz kaldığı sürenin, yapı elemanının işlevinin ve mevcut durumunun belirlenmesi gerektiği belirtilmektedir. Çevresel etmenler ise öncelikle (i) iç ve (ii) dış etmenler olarak ikiye ayrılmaktadır. Bina elemanlarını etkileyen dış çevresel etmenler ağırlıklı olarak donma-çözünme, rüzgar, güneş ışınımı, sıcaklık, yağış ve gazlar gibi atmosferik etmenlerdir. İç çevresel etmenler ise tasarım, uygulama ve kullanım ile ilişkili etmenlerdir.

Çalışmada, öncelikle atmosferik dış çevresel etmenlere ilişkin veriler Devlet Meteoroloji İşleri Genel Müdürlüğü ve WUFI 4 yazılımının veritabanındaki verilerden yararlanarak derlenmiştir. Buna göre; İstanbul’da görülen yıllık ortalama, en yüksek ve en düşük hava sıcaklıkları sırasıyla 14,3 C^o, 31,5 C^o ve -3,5 C^o; yıllık ortalama, en yüksek ve en düşük bağıl nem sırasıyla %76, %100 ve %41’dir. Güneş ışımını binaların en çık güneybatı ve batı cephelerini, rüzgarla itilen yağmur ise kuzeybatı cephesini etkilemektedir.

Bina elemanlarını etkileyen ve ağırlıklı olarak kullanım ve bakım-onarım kaynaklı iç çevresel etmenlere ilişkin veriler ise, malzeme üreticileri ve yükleniciler ile bağlantı kurularak 'paket sistem uygulanmış binalar' envanterinin oluşturulması sonrasında bina işletme görevlileri ile görüşülerek derlenmiştir. Uygulamaların mevcut durumlarının belirlenmesinde görsel inceleme yönteminden yararlanılmış ve paket dış cephe yalıtım sistemi uygulamalarının İstanbul'daki uzun dönemli dayanımını ortaya koymak üzere genel bir değerlendirme yapılmıştır.

Farklı yaşlardaki dış cephe ısı yalıtım uygulamalarının mevcut durumunu tespit etmek üzere yapılan görsel incelemeler, 2008 yılının sonbahar ve kış aylarında dokuz bina grubunda, toplam 44 binada gerçekleştirilmiştir. Bina gruplarının iki tanesi İstanbul'un Avrupa yakasında, diğerleri Anadolu yakasındadır ve incelenen tüm binalar konut binalarıdır. İncelenen binalardaki paket sistem uygulaması; dübel ve yapıştırıcı ile betonarme taşıyıcı sistem bileşenlerine ve tuğla dolgu duvarlara tespit edilen 3 veya 4 cm kalınlığındaki haddelenmiş polistren ısı yalıtım levhalarından ve bunlar üzerine uygulanan cam elyafından sıva teli, astar ve mineral esaslı sıva katmanlarından oluşmaktadır. Uygulamaların yaşları 1 ile 12 yıl arasında değişmektedir.

Genel değerlendirmeye esas olan incelemelerde, binaların tüm cepheleri zemine yakın katlarda çıplak göz ile, üst katlarda ise dürbün ile incelenmiş, cephelerin genel görünümü ve görülen her hasar fotograf ile kayıt altına alınmıştır. Görülen hasarların gruplanmasında öncelikle hasara neden olan etmenin kaynağına göre, diğer bir anlatımla ISO 6241: 1984 standardında belirtildiği gibi dış ya da iç çevresel etmen kaynaklı hasarlar olarak gruplama yapılmıştır. Dış çevresel etmen kaynaklı hasarların gruplanmasında Künzel vd.lerinin kullandığı; hasarın varlığına, tipine ve yoğunluğuna dayalı üç gruptan oluşan sınıflamadan yararlanılmıştır. Buna göre; (i) görünür hiçbir hasarın olmadığı veya normal uzaklıktan zor seçilen küçük çizgisel çatlakların olduğu durum 'hemen hemen hasarsız', (ii) ancak yakın incelemede görülebilen, pencere kenarlarındaki veya ısı yalıtım levhaları arasındaki sınırlı sayıda çatlakların olduğu durum 'az hasarlı', (iii) uzun ya da sık çatlakların olduğu, sıva veya astar tabakalarında kabarmaların ya da kopmaların olduğu durum ise 'çok hasarlı' olarak sınıflandırılmıştır. İç çevresel etmenlerden kaynaklanan hasarlar ise hasarın varlığına bağlı olarak (i) hasarlı ve (ii) hasarsız olmak üzere iki gruba ayrılmıştır.

44 binanın dış çevresel etmenlerin etkisi açısından incelenmesi sonucunda; 1 ile 7 yaş arasındaki 21 paket sistem uygulamasının 'hemen hemen hasarsız' olduğu, 12 yaşındaki 23 paket sistem uygulamasının ise 'az hasarlı' olduğu görülmüştür. Az hasarlı uygulamaların iç yüzeylerinde yapılan görsel incelemede hasarların iç yüzeyde gözle görülebilen herhangi bir hasara yol açmadığı belirlenmiş, kullanıcılarla yapılan görüşmelerde de iç ortam ısıl konfor koşullarında bir değişime neden olmadığı öğrenilmiştir. Bu doğrultuda paket dış cephe ısı yalıtım sistemlerinin İstanbul'un atmosferik koşullarında 12 yıla kadar ısıl ve nemle ilişkili performansında azalma olmadığı söylenebilir.

Binaların uygunsuz kullanım, hatalı tasarım ve yapımı kapsayan iç çevresel etmenlerin etkisi açısından incelenmesinde; yüzey kaplamasında ayrılma ve kopma, ısı yalıtım malzemesinin atmosfer koşullarına maruz kalması, matkap delikleri gibi çok sayıda hasar ile karşılaşılmıştır. Bu tip hasarlar aynı zamanda sistemi oluşturan bileşenlerde erken yaşlanma ve dolayısı ile uzun dönemli performansında azalma riskini arttırmaktadır. Bu doğrultuda mimarların, yüklenicilerin ve kullanıcıların sırasıyla uygun detaylandırma, yapım ve kullanım konusunda bilgilendirilmelerinin önemli olduğu söylenebilir. Ek olarak uygulamaların düzenli bakım-onarımının yaygın olmadığı dikkate alındığında, işletme görevlilerini bu tarz hasarları onarmak üzere düzenli bakım yaptırılması gerektiği konusunda bilgilendirilmeleri de önem taşımaktadır.