The usage of local material with environmental recycled origin for manufacturing fire rated wooden doors

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Introduction

In accordance to the current period in EGYPT & the new national huge projects & the need for compatibility with the international specifications & codes in the safety & fire protection procedures requires using fire rated doors for the different fire rated zones in such projects.

Thus, due to the availability of the environmental recycled material in EGYPT like molasses & wood particles, this issue encourages the researcher to use such kinds of products in the production of recycled wooden fire rated doors.

After survey on the local market it was observed that all fire rated doors are exported according to the British or the American codes, according to that survey the researcher design & manufactures & test one type of doors using the previous mentioned materials, to be used in the Nile hotel " KEMPINESKI" project in the Housing & Building National Research center which accepted the usage of such doors in the project mentioned.

Therefore, this research has an important impact as a first step to depend upon the local products instead of the exported ones which helps in reducing the frequent use of foreign currency as well as providing lot of jobs promoting investments in such projects & reduce the financial burdens upon the project budget that need such products.

Research problem: -

- Shortage of local made fire rated doors.
- Lake of using of recycled materials in wood working items.
- The continuous increase of the fire rated doors in Egypt.
- Meeting the accreditation of foreign labs for testing fire rated door.

Research objectives: -

The research targets producing fire rated wooden doors depending on the recycled environmental materials, depending on official testing laboratory located in Egypt to license fire rated doors.

Research Importance

- The possession of the identity to produce an Egyptian fire rated wooden doors.
- Provide jobs opportunity depending on the products manufactured in the Egyptian factories.
- Helps to save foreign currency through manufacturing that kind of doors locally with local materials.

Research limits: -

The research is limited to the study of the design, specification of the British fire rated doors& also limited to the fire rated wooden doors manufactured from Egyptian recycled materials.

Research methodology: -

The research follows the following syllabuses: -

- The survey method throughsurveying the Egyptian market of fire rated doors.
- Experimental syllabus through testing the fire rated wooden door

Research subject: -

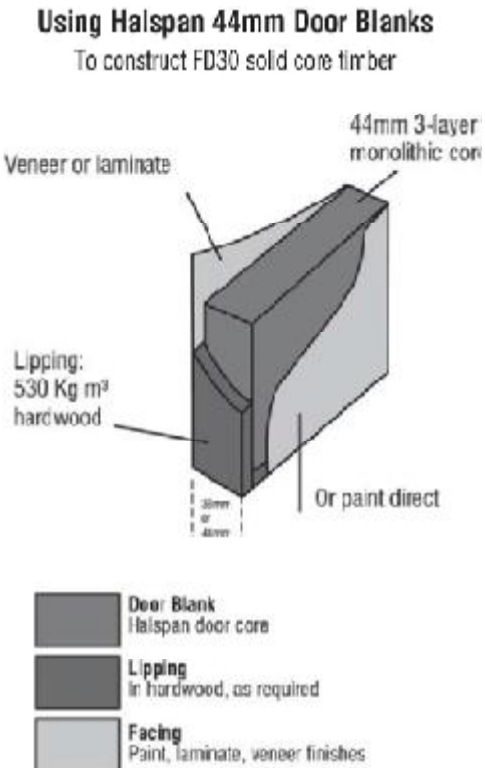
The core in that study is a case study the researcher goes through it by applying a fire rate testing to a door leaf designed by him in an attempt to manufacture a fire rated wooden door according to the international codes with some local recycled materials, thus the British fire rated wooden specification has to be clearly illustrated as follows: -

30 minutes British Fire rated doors materials

The fire rated materials are categorized to 3 categories: (Dwg 1) Leaf, frame, accessories these categories will be demonstrated as follows :

Door Leaf: (figure 1)

The core of the door is manufactured from a particle core from Halspan company consists of 3 layers from fibers treated with some chemical components tested & certified from the international labs like BM- Trada & Intertek companies & its dimensions are 240*110*4.4 cm with a density of 620 kg/m3.



(Figure 1)

Components of door leaf according to British standards

Door Frame: -

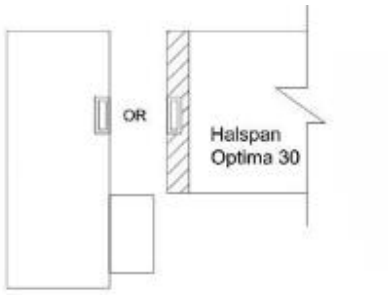
(Figure2) different materials may be used in the frame of the door but we will use in the research the hard wood frame with a dimensions of 14*4.5*214 cm & a density of 550 kg/m3 according to British codes – BS476 Part 22

(Figure 2) section of the door frame according to the British standards

Doors accessories splits into two parts

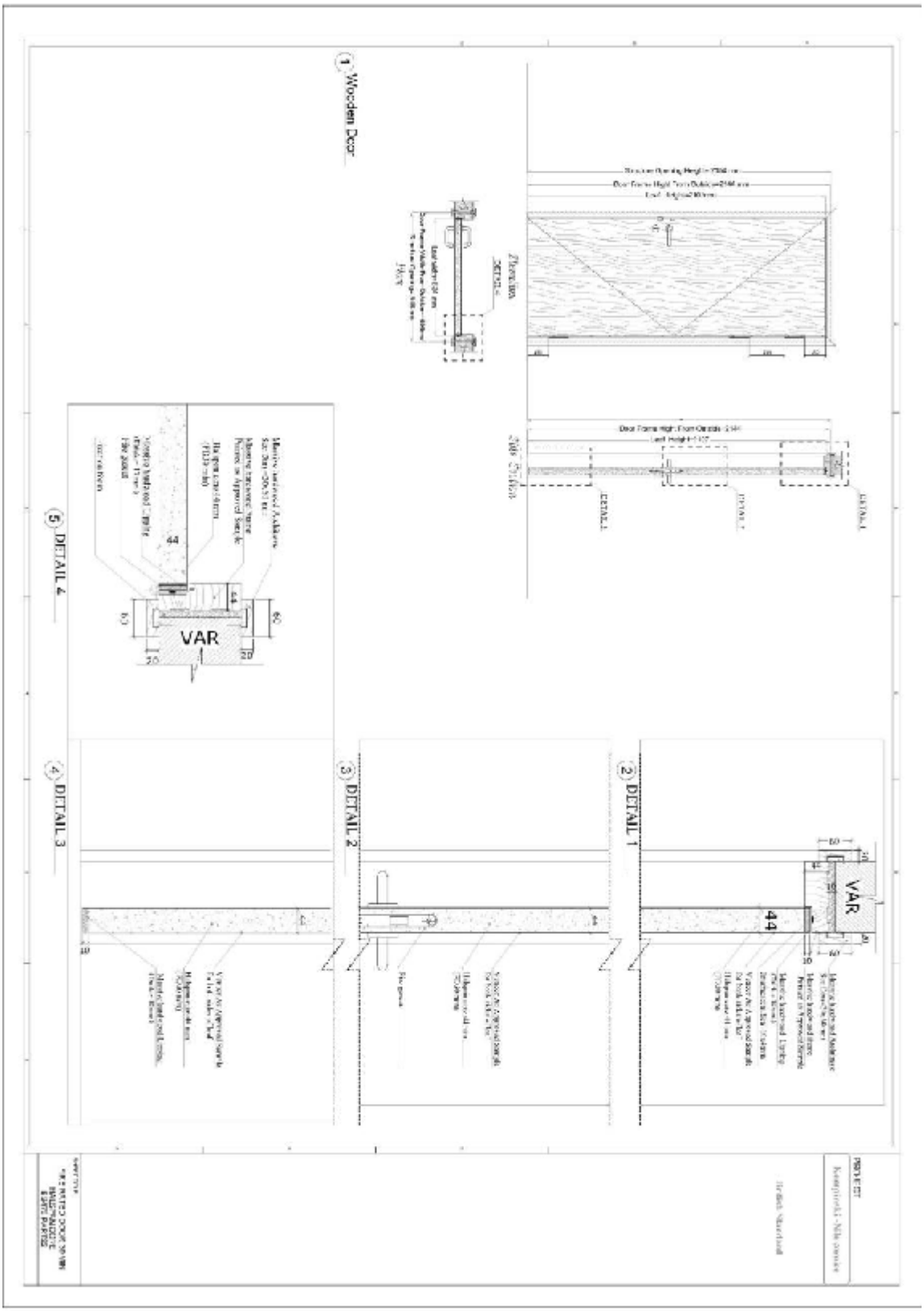
a- Intumescent strips with a dimensions of 4 * 11 mm fixed to a groove on the edges of door leaf it helps to prevent fumes & flames leakage from spaces between door & frame (figure 3)

b- Other accessories as hinges door locks automatic door closer or any other as specified are fixed inside special gasket to prevent leakage of fumes & flames from the offcuts for that accessories.



Jamb: Door widths up to 950mm - 10x4 seal

(Figure 3 door section illustrates the intumescent strips according to the British standards)



drawing 1 the design of the fire rated door according to british standards

Experimental sample Fire rated doors materials (researchsubject)

The fire rated materials are categorized to 3 categories: (Dwg 2) Leaf, frame, accessories these categories will be demonstrated as follows :

Door Leaf:

Door leaf consists of 3 layers of cheep board 18mm + 16 mm + 18 mm thickness compressed with a total dimensions of 122 * 2400 * 5 cm & a density of 650 kg/m3.

Door Frame: -

Different materials may be used in the frame of the door but we will use in the research the hard wood frame with a dimensions of 14*4.5*214 cm & a density of 550 kg/m3 according to British codes – BS476 Part 22

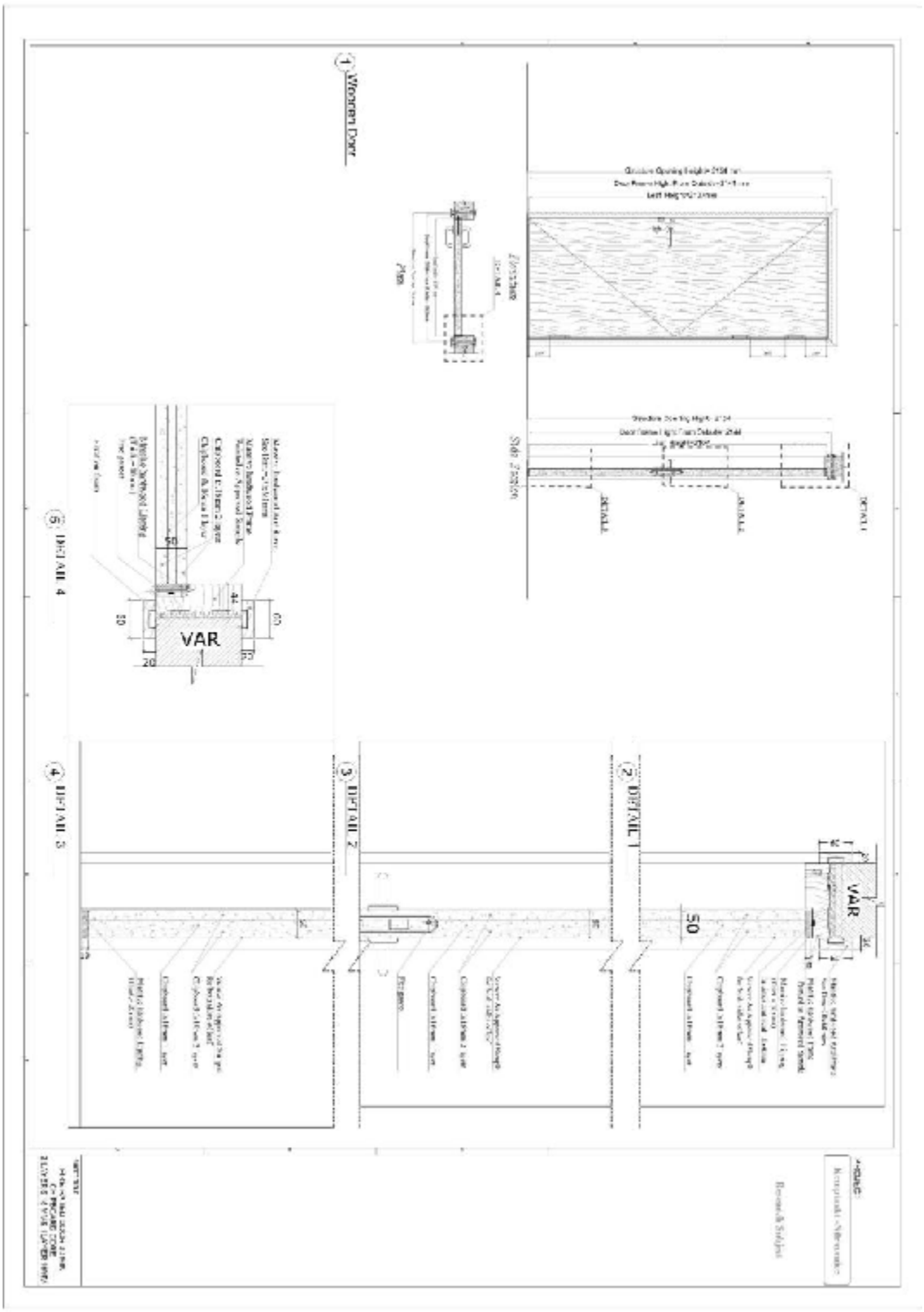
Doors accessories splits into two parts

c- Intumescent strips with a dimensions of 4 * 11 mm fixed to a groove on the edges of door leaf it helps to prevent fumes & flames leakage from spaces between door & frame (figure 3)

d- Other accessories as hinges door locks automatic door closer or any other as specified are fixed inside special gasket to prevent leakage of fumes & flames from the offcuts for that accessories.

Door leaf manufacturing steps:-

- Calibrating:- in this step the 3 sheets are calibrated to get the targeted thickness , this step is completed though sanding machine.
- Door pressing :- in this step the 3 sheets of sheep board are compressed together in the hydrolytic press using urea formaldehyde as an adhesive this step takes 20 min.
- Lipping :- in this step the door gets its hard wood lipping with a thickness of 1 cm through automatic edge banding machine.
- Veneer pressing :- the required veneer is pressed upon the door using urea formaldehyde glue.



Drawing – 2 drawings illustrates the desigen of the fire rated door

Testing Stage:-

The sample door is fixed in the test area in the housing & building national center laboratory according to the following codes :-

(ASTM E119)

(ASTM E 2074-00)[1]

(NFPA 80)

(NFPA 252)

(UBC – 7-2)

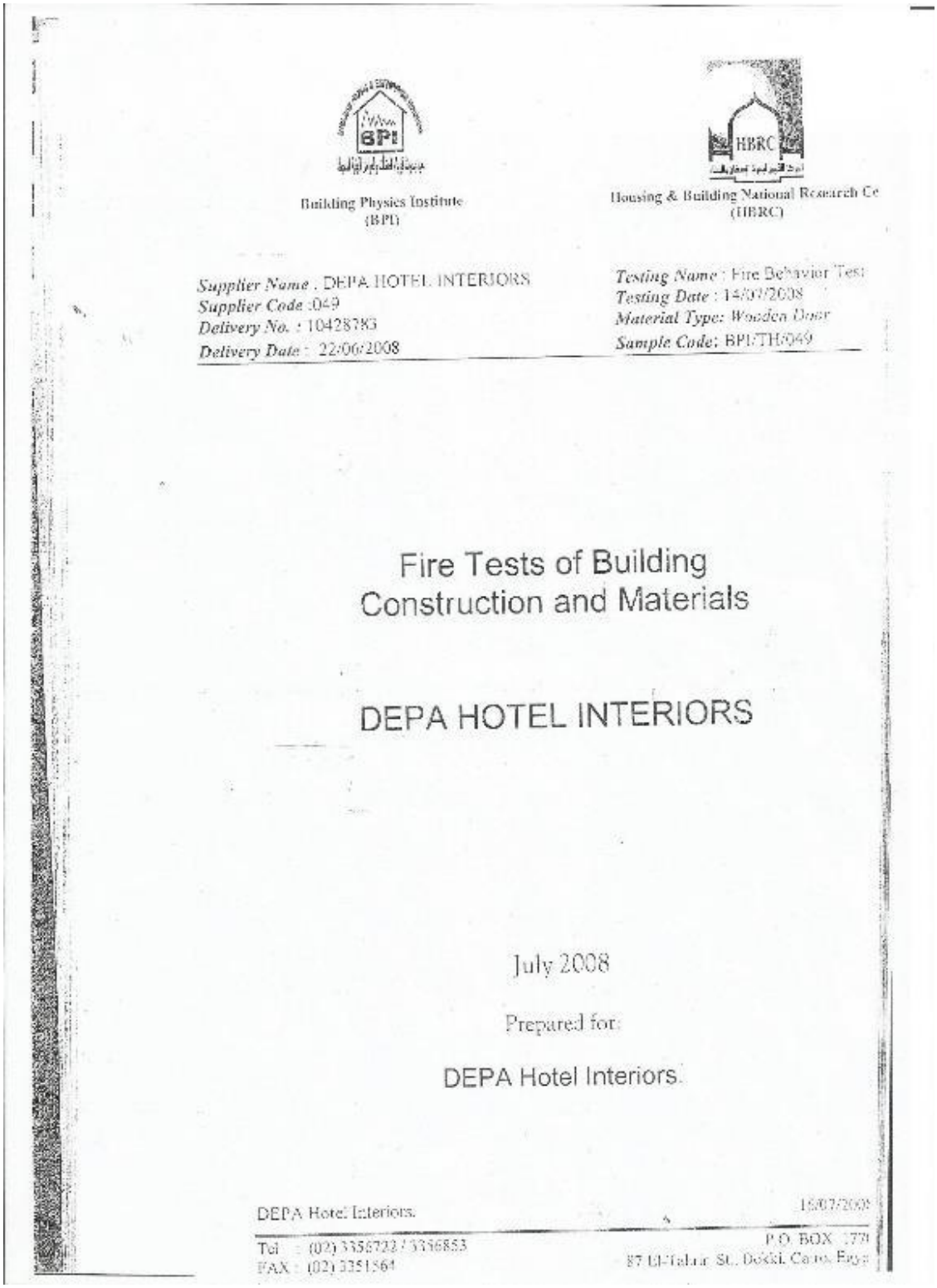
(UL 9)

(ULC STANDARD CAN4 – S104)

The testing procedures for the door research point as the following report of the housing & building national center laboratory as follows :-

[1] Nat. Bur. Stand. (U.S.), prod. Stand. 51 – 71, 18 pages (January 1972)

Report of the housing & building national research center



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Supplier Name : DEPA HOTEL INTERIORS
Supplier Code :049
Delivery No. : 10428783
Delivery Date : 22/06/2008

Testing Name : Fire Behavior Test
Testing Date : 14/07/2008
Material Type: Wooden Door
Sample Code: BPI/TH/049

Fire Tests of Building Construction and Materials

DEPA HOTEL INTERIORS

July 2008

Prepared for:

DEPA Hotel Interiors.

DEPA Hotel Interiors. 15/07/2008

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INTRODUCTION

The test samples identification is as provided by the client. Building Physics Institute (BPI) accepts no responsibility for any inaccuracies therein. BPI did not select the test samples and has not verified the composition, manufacturing techniques or quality assurance procedures.

The performance of walls, columns, floors, and other building members under fire exposure conditions is an item of major importance in securing constructions that are safe, and that are not a menace to neighboring structures or to the public. Recognition of this is registered in the codes of many authorities, municipal and other. It is important to secure balance of the many units in a single building, and of buildings of like character and use in a community; and also to promote uniformity in requirements of various authorities throughout the country. To do this it is necessary that the fire-resistive properties of materials and assemblies be measured and specified according to a common standard expressed in terms that are applicable alike to a wide variety of materials, situations, and conditions of exposure.

Such a standard is found in the methods that follow. They prescribe a standard exposing fire of controlled extent and severity. Performance is defined as the period of resistance to standard exposure elapsing before the first critical point in behavior is observed. Results are reported in units in which field exposures can be judged and expressed.

The methods may be cited as the "Standard Fire Tests," and the performance or exposure shall be expressed as "2-h, 6-h, 1/2-h, etc".

When a factor of safety exceeding that inherent in the test conditions is desired, a proportional increase should be made in the specified time-classification period.

The ASTM E119 test procedure is identical or very similar to the following standard test methods:

A. American Society for Testing and Materials (ASTM):
   1. ASTM E119 Methods for Fire Tests of Building Construction and Materials.
   2. ASTM E2074-00 Methods of Fire Tests of Door Assemblies.
   3. E2010-01 Methods for Fire Tests of Window Assemblies.

B. National Fire Protection Association (NFPA):
   1. NFPA 80: Fire Doors and Windows.
   2. NFPA 251: Fire Tests of Building Construction and Materials.
   3. NFPA 252: Fire Tests of Door Assemblies.
   4. NFPA 257: Fire Tests of Window Assemblies.

C. Uniform Building Costs (UBC):
   1. UBC-7-1: Methods for Fire Tests of Building Construction Materials.
   2. UBC 7-2: Methods for Fire Tests of Door Assemblies.
   3. UBC-7-4: Methods for Fire Tests of Window Assemblies.

D. Underwriters Laboratories, Inc. (UL)
   1. UL 9: Fire Tests of Door Assemblies.
   2. UL 10C: Fire Tests of Window Assemblies.
   3. UL 263: Fire Tests of Building Construction and Materials.

E. Standard Council of Canada:
   1. ULC Standard CAN4-S101: Fire Tests of Building Construction and Materials.
   2. ULC Standard CAN4-S104: Fire Tests of Door Assemblies.
   3. ULC Standard CAN4-S106: Fire Tests of Window Assemblies.

1. Scope

1.1 These methods are applicable to assemblies of masonry units and to composite assemblies of structural materials for buildings, including bearing and other walls and partitions, columns, girders, beams, slabs, and composite slab and beam assemblies for floors and roofs. They are also applicable to other assemblies and structural units that constitute permanent integral parts of a finished building.

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1.2 It is the intent that classifications shall register performance during the period of exposure and shall not be construed as having determined suitability for use after fire exposure.

1.3 This standard should be used to measure and describe the properties of materials, products, or assemblies in response to heat and flame under controlled laboratory conditions and should not be used to describe or appraise the fire hazard or fire risk of materials, products, or assemblies under actual fire conditions. However, results of this test may be used as elements of a fire risk assessment which takes into account all of the factors which are pertinent to an assessment of the fire hazard of a particular end use.

Note 1 - A method of fire hazard classification based on rate of flame spread is covered in ASTM Method E84, Test for Surface Burning Characteristics of Building Materials.

1.4 The results of these tests are one factor in assessing fire performance of building construction and assemblies. These methods prescribe a standard fire exposure for comparing the performance of building construction assemblies. Application of these test results to predict the performance of actual building construction requires careful evaluation of test conditions.

2. Significance

2.1 This standard is intended to evaluate the duration for which the types of assemblies will contain a fire, or retain their structural integrity or exhibit both properties dependent upon the type of assembly involved during a predetermined test exposure.

2.2 The test exposes a specimen to a standard fire exposure controlled to achieve specified temperatures throughout a specified time period. In some instance, the exposure, however, may not be representative of all fire conditions which may vary with changes in the amount, nature and distribution of fire loading, ventilation, compartment size and configuration, and heat sink characteristics of the compartment. It does, however, provide a relative measure of fire performance of comparable assemblies under these specified fire exposure conditions. Any variation

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from the construction or conditions (that is, size, method of assembly, and materials) that are tested may substantially change the performance characteristics of the assembly.

2.3 The test standard provides for the following:
2.3.1 In Doors, Windows, walls, partitions and floor or roof assemblies:
2.3.1.1 Measurement of the transmission of heat.
2.3.1.2 Measurement of the transmission of hot gases through the assembly, sufficient to ignite cotton waste.

2.4 The test standard does not provide the following:
2.4.1 Full information as to performance of assemblies constructed with components or lengths other than those tested.
2.4.2 Evaluation of the degree by which the assembly contributes to the fire hazard by generation of smoke, toxic gases, or other products of combustion.
2.4.3 Measurement of the degree of control or limitation of the passage of smoke or products of combustion through the assembly.
2.4.4 Simulation of the fire behavior of joints between building elements such as floor-wall or wall-wall, etc., connections.
2.4.5 Measurement of flame spread over surface of tested element.
2.4.6 The effect of fire endurance of conventional openings in the assembly that is electrical receptacle outlets, plumbing pipe, etc., unless specifically provided for in the construction tested."

TEST PROCEDURE

- The tested sample was prepared with specified dimensions and size to comply with those of the furnace chamber.
- Three thermocouples of type T (copper- constantan) were fixed on the unexposed surface of the door leaf. They had been used to record the average temperature of the unexposed face.
- Nine thermocouples of type K (chromel-alumel) were fixed inside the furnace. They had been used to record the average temperature of the furnace.

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- The furnace temperature was controlled to achieve specified temperatures through out a specified time period according to requirements of ASTM E-119.
- Measured temperatures of the unexposed surface were recorded periodically at intervals not exceeding 5 minutes. The average temperature was calculated.
- The tested sample was located in its place to act as the front side of the furnace. A suitable mechanism must used to ensure tight and safe fixation of tested sample.
- The test stopped when the average temperature of the unexposed surface reached 140°C above the ambient temperature or any sudden cracks had been appeared, and the results were reported.
- The DEPA hotel interiors door assembly (I) and (II) had been tested to achieve 20 and 45 minutes fire rated respectively as requested by the customer.

Conditions of Acceptance

Regard the test as successful when the following conditions are met:

1. The tested sample has withstood the fire endurance test without passage of flame or gases hot enough to ignite cotton waste, for a period equal to that for which classification is desired.
2. Transmission of heat through the tested sample during the fire endurance test shall not have been such as to raise the average temperature on its unexposed surface more than (140°C) above its initial temperature.
3. Where the conditions of acceptance place a limitation on the rise of temperature of the unexposed surface, the temperature end point of the fire endurance period shall be determined by the average of the measurements taken at individual points; except that if a temperature rise of 30% [(180°C) above initial temperature] in excess of the specified limit occurs at any one of these points, the remainder shall be ignored and the fire endurance period judged as ended.

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TEST RESULTS AND OBSERVATIONS

Door leaf (I):

- The tested sample was placed in front of the test furnace on June 29, 2008. The door assembly identification is as provided by the client. The construction and dimensions in details of the tested sample was shown in figure (1).
- The dimension of the door leaf is 920×2102×50 mm.
- Figure (2, 3) shows the photos of the both sides of the tested sample before the test.
- The door leaf delivered to the laboratory for testing without some of accessories such as the door closer and set of the door lock.
- The door closer and set of the door lock positions are filled with the door core material.
- **Bad installation was observed due to:**
  - High clearance between the door leaf and door frame.
  - Loose fixation of the upper side hinged, leads to soft hammering of the door leaf to fit it in the frame.
  - Wrapping of the door leaf.
- The smoke was observed at the clearance between the upper edge of the door leaf with the frame, and also near the upper side hinged as shown in figure (4). Hence, a continuous smoke generation was observed allover the test period.
- Burning of the upper leaf edge was observed near the end of the test without any passage of flame.
- Figure (5) shows the temperature measurements taken at individual points of the unexposed surface during the test. Figure (6) shows minimum, maximum and the average temperature of the unexposed surface.

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- Figure (7) shows the standard time – temperature curve, the actual furnace temperature and the average temperature of the unexposed surface.
- After 22 minutes the test was ended due to appearance of cracks as shown in figure (8), although the unexposed surface temperature was not exceeds the limits mentioned in the conditions of acceptance
- Figures (9, 10) show the photos of the tested sample after the test.

Door leaf (ff):

- The tested sample was placed in front of the test furnace on July 13, 2008. The door assembly identification is as provided by the client. The construction and dimensions in details of the tested sample was shown in figure (11).
- The dimension of the door leaf is 834×2107×50 mm.
- Figure (12) shows the photo of the tested sample before the test.
- The door leaf delivered to the laboratory for testing with door lock set and without door closer. The door closer position is filled with the door core material.
- After 30 minutes of starting the test, Burning of the upper leaf edge and from the door lock set was observed without any passage of flame as shown in figure (13).
- Figure (14) shows the temperature measurements taken at individual points of the unexposed surface during the test. Figure (15) shows minimum, maximum and the average temperature of the unexposed surface.
- Figure (16) shows the standard time – temperature curve, the actual furnace temperature and the average temperature of the unexposed surface.
- After 35 minutes the test was ended due to appearance of flame from the upper edge of the door as shown in figure (17), although

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the unexposed surface temperature was not exceeds the limits mentioned in the conditions of acceptance

- Figure (18) show the photo of the exposed surface of the tested sample after the test.

CONCLUSION

Property	Result	Remark
Fire rating of door (I)	22 minutes	
Fire rating of door (II)	35 minures	

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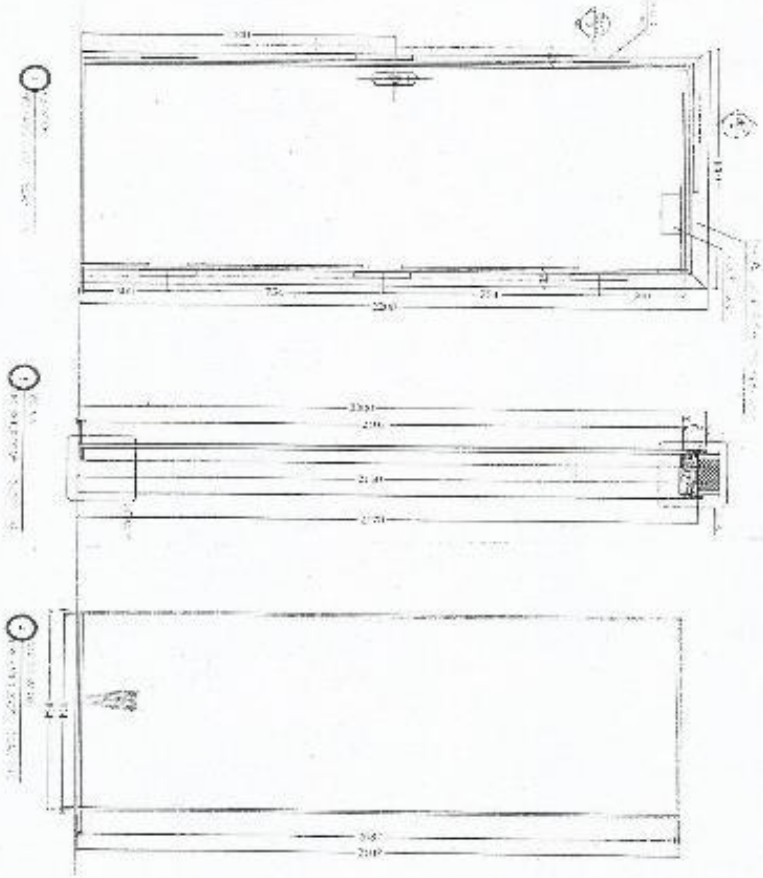

Figure (11): The door (I) assembly construction drawing

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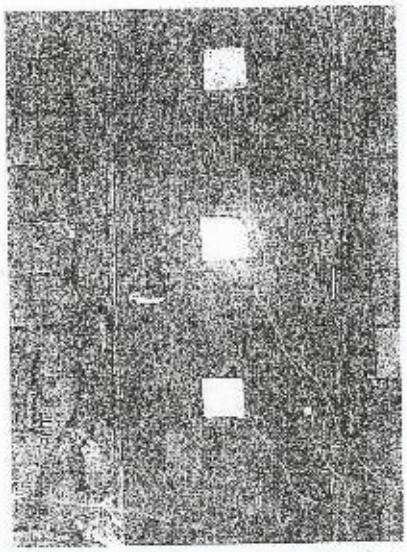

Figure (12): The photo of the unexposed surface of the door (11) assembly before the test

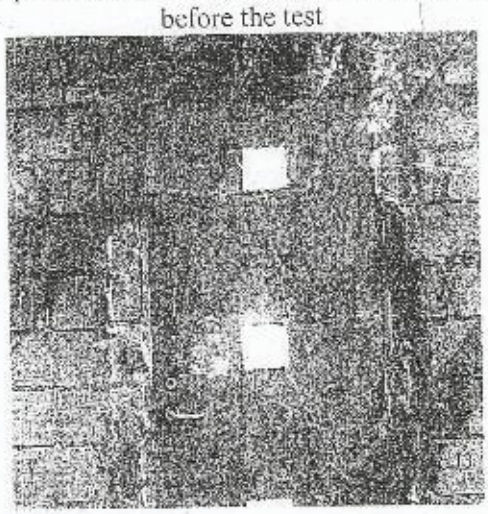

Figure (13): The photo of the unexposed surface of the door (11) assembly during the test

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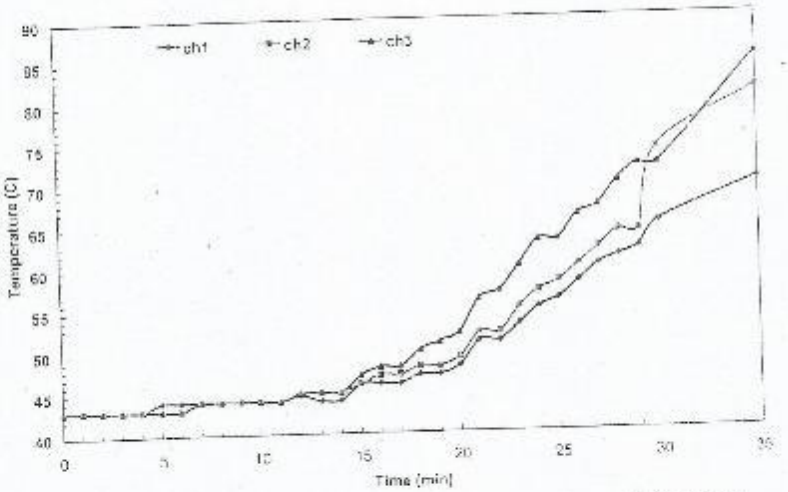

Figure (14): The unexposed surface temperature of door (II)

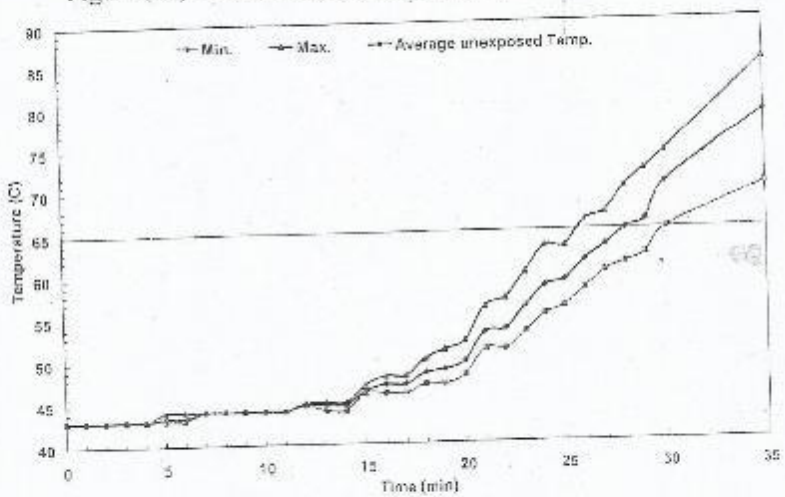

Figure (15): The minimum, maximum, and average of the unexposed surface temperature of door (II)

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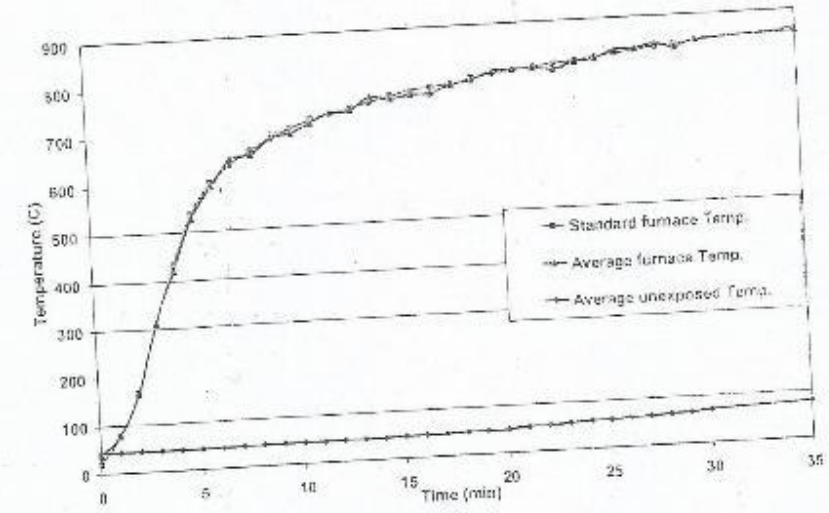

Figure (16): The standard time – temperature curve, the actual furnace temperature and the average temperature of the unexposed surface of door (II)

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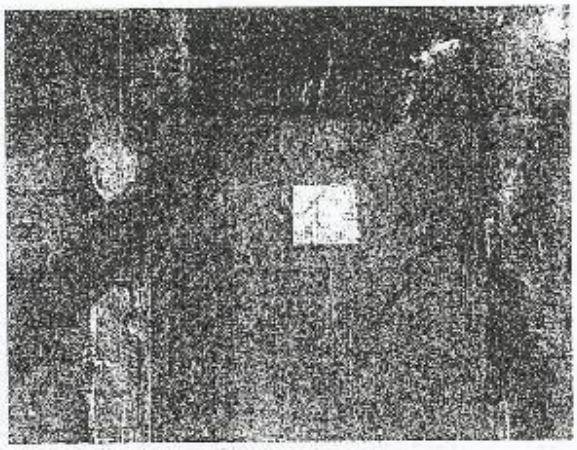

Figure (17): The photos of the unexposed surface of the door (II) assembly after the test.

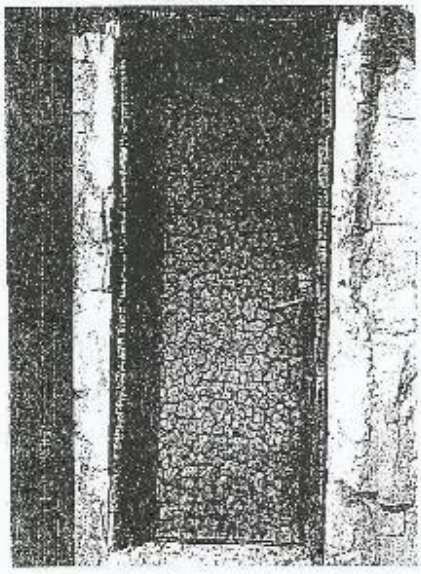

Figure (18): The photo of the exposed surface of the door (II) assembly after the test.

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بينو ميروني
للصناعات الخشبية والمعدنية
س.ت : ٣٦٦٤ الجيزة

التاريخ : ٢٠١٥/١٢/٠٧

شهـــــــــــادة

إلى من يهمه الامر

تحيه طيبه وبعد ،،،

تشهد شركه بينو ميرونى للصناعات الخشبيه والمعدنيه إحدى شركات مجموعة ديبا للفنادق أن د. أحمد عبد العزيز أمين قام بتصميم و عمل الرسومات و حضور الإختبارات الخاصه بالأبواب المضادة للحريق المطلوبه لمشروع فندق النيل بالقاهرة وقد إجتازت الإبواب الإختبارات المطلوبه حسب التقرير المرفق.

و قد حررت هذه الشهاده بناءاً على طلبه دون أدنى مسئوليه على الشركة.

م. محمد الزكي

العضو المنتدب

Certificate illusttes the researcher door design

Results: -

1- Success of the fire rated test with a period of 35 minutes which exceeds the requested time by 5 minutes.
2- The availability of using local recycled materials in manufacturing fire rated wooden doors.
3- Reduces the usage of foreign currency used in exporting that kinds of products.

Comparisonfield	**Research door**	**British door**
Wood type	Cheep board	Halspan sheet
Wood density	650 kg/m3	620 kg/ m3
Dimensions	122* 244 cm	240 * 110 cm
Fire rate time	35 min	30 min
Core cost	420 EGP	900 EGP
Frame wood	Solid wood	Solid wood
Framedensity	550 kg/m3	550 kg/m3
Accessories used	According British codes	According British codes
Testing codes	(ASTM E119) (ASTM E 2074-00) (NFPA 80) (NFPA 252) (UBC – 7-2) (UL 9) (ULC STANDARD CAN4 – S104)	BS 476 PART 22 (1987)

Table 1 illustrates the results of the fire test for the sample door & the door according the British standards

Recommendations: -

- Using locally manufactured fire rated doors.
- Egyptian labs should be acknowledged from the local authorities to certify fire rated doors.

References: –

Halspan Technical support manualsupport @haslspan.com 2015

Intertek Warnock Hersey – www.intertek.com – 2015

الاخشاب المستخدمة فى التشييد والبناءد.اسامة عبد النبى قنبر ٢٠١٣

المركز القومى لبحوث الاسكان والبناء – اختبار مقاومة الحريق لأبواب خشب – يوليو ٢٠٠٨

[1] Nat. Bur. Stand. (U.S.), prod. Stand. 51 – 71, 18 pages (January 1972)