

JAMAICA FIRE BRIGADE TRAINING DEPARTMENT



BUILDING CONSTRUCTION AND STRUCTURAL FIRE PROTECTION MODULE

BUILDING MATERIALS

The characteristics of individual components of a building will be affected by other components, especially in a fire situation. Firefighters are taught to detect signs of dangerous developments in a building and they should enlarge this knowledge by experience and observation.

Firefighters must, therefore, try to be as familiar as possible with the properties of materials in so far as they could affect the safety of the public, themselves and the building

There are an almost infinite variety of different fire situations, which could involve any material, which will relate to:

- i. the severity of the fire
- ii. how long the material has been involved
- iii. the position of the material eg. wall, floor, ceiling, cladding, suspended.
- iv. How the material is fixed to adjoining material
- v. reaction between the adjoining materials
- vi. the reaction of the material to the extinguishing medium used
- vii. the standard of construction and workmanship.

Primarily, it is the contents of a building that give rise to the danger of fire.

FIRE TESTING

General

The principle is to provide for the health, safety and welfare of people and is not, primarily, for safeguarding property or limiting economic loss. The requirement of regulations can be put under the following headings

- i. means of escape
- ii. internal fire spread (surfaces)
- iii. internal fire spread (structures)

- iv. external fire spread
- v. access and facilities for the Fire Service

Some Details of the Parts of the Standard

The present main properties, which are thought to influence the behavior of building materials when involved in fire, are:

- i. combustibility
- ii. ignitability
- iii. fire propagation
- iv. rate of surface spread of flame

GENERAL NOTES ON ELEMENTS OF STRUCTURE

1. Building Regulations 1991

- B1 Means of escape
- B2 Internal fire spread (linings)
- B3 Internal fire spread (structure)
- B4 External fire spread
- B5 Access and facilities for the Fire Service.

2. Functional Requirements

- B1. "The building shall be designed and constructed so that there are means of escape, in case of fire, from the building, to place of safety outside the

building, capable of being safely and effectively used at all material times.”

B2. “To inhibit the spread of fire within the building the internal linings shall:

- i. resists the spread of flame over their surfaces and
- ii. have, if ignited, a rate of heat release which is reasonable in the circumstances.

“Internal linings” mean the materials lining any partition, wall, ceiling or other internal structure.

B3. i. “The building shall be designed and constructed so that, in the event of fire, its stability will be maintained for a reasonable period”.

ii. “A wall common to two, or more, buildings, shall be designed and constructed so that it resists the spread of fire between those buildings”.

iii. “To inhibit the spread of fire within a building it shall be sub-divided with fire-resisting construction to an extent appropriate to the size and intended use of the building”.

iv. “The building shall be designed and constructed so that the unseen spread of fire and smoke, within concealed spaces in its structure and fabric, is inhibited”.

B4. i. “The external walls of the building shall resist the spread of fire over the walls and from one building to another having regard to the height, use and position of the building”.

ii. “The roof of the building shall resist the spread of fire over the roof and from one building to another having regard to the use and position of the building”.

B5. i. The building shall be designed and constructed so as to provide facilities to assist the firefighters in the protection of life”.

iii. Provision shall be made within the site of the building to enable fire appliances to gain access to the building”.

3. Definition of Elements of Structure

a. Approved Document "B" of the Building Regulations defines elements of structure as being:

- i. any member forming part of the structural frame of a building (Fig. 3.(1)) or any beam or column not being a member forming part of a roof structure only;
- ii. a floor (3) including a compartment floor but not the lowest floor of the building or a platform floor;
- iii. an external wall (4)
- iv. separating wall (5)
- v. a compartment wall (6)
- (vi) a structure enclosing a protected shaft (7)
- (vii) a load-bearing wall or load-bearing part of a wall (8)
- (viii) a gallery (9)

The other elements such as stairs, roofs, partitions doors etc., which are also necessary to complete a building.

The function of each of the elements of structure, in the majority of buildings, is to carry the loads placed upon them.

The loads are principally,

- a. The “Dead Load” which is the weight of all parts of the building itself which is imposed on the elements. These are constant.
- b. The “Imposed Load” which consists of the people, furniture, machinery and materials expected to be in the building when it is occupied, these loads are variable.
- c. The “Wind Load” which means all loads due to the effects of wind pressure or suction.

How loads are imposed:

Axial Loads: A force whose resultant passes through the centroid (or centre of mass) of the section under consideration and is perpendicular to the plane of the section. An axial load is straight and true, all other conditions being equal, a structure will sustain its greatest load is axial.

Eccentric Loads: A force whose resultant is perpendicular to the plane of the section but does not pass through the center of the section, thus bending the supporting member

Torsional Loads: forces that are offset from the shear centre of the section under consideration and are inclined towards or line in the plane of the section, thus twisting the supporting member.

How Loads Are Applied

(i) **Compression:** Compressive forces are crushing, pushing the mass of the material together

(ii) **Tensile forces** tend to pull the material apart.

(iii) **Shear:** Shear forces tend to cause the molecules of the material to slide past one another.

4. The Factor of Safety

The existence of a factor of safety in all well built structures is useful to a firefighter. An experienced firefighter may be able to judge, within limits, the extent to which the factor of safety has been reduced by burning, heat or distortion of various parts of the building.

By an assessment of the remaining factor of safety the firefighter may be able to decide whether it is safe to work, in a fire, underneath parts of the structure, which have been partially destroyed.

By the destruction of some support, a beam could become a cantilever and still retain enough strength to be safe. Wall and columns have to carry not only the vertical loads but also to withstand the overturning effects imposed by winds loads and by eccentric loading.

Many of the stresses in a building are altered in a fire for heat affects different building materials in different ways. Readily flammable materials such as wood may simply burn, although this will depend largely on their cross-sectional area. Metals will expand, distort or melt. Concrete and stone may contract, expand or violently disintegrate. Sudden cooling after heating can cause cast-iron or stone to crack and floor loads are often vastly increased by debris and the weight of water ported into the building.

In a fire all these changes will be taking place simultaneously. An ability to interpret the inter-reactions comes with experience and firefighters should take every opportunity to learn. A minor collapse in one part can trigger a large collapse, a dust explosion, a release of chemicals, gas, etc.

A building reduced to its simplest essential may usually be said to consist of: foundation to transmit the load of the structure to the ground without appreciable movement or shifting, walls, floors and roof. It has been said that a structure does not become a building until it possesses a roof.

TRUE ELEMENTS OF STRUCTURE

1. Fire Resistance

Premature failure of the structure can be prevented by provisions for loadbearing elements of structure to have a minimum standard of fire resistance, in terms of resistance to collapse or failure of loadbearing capacity. The purpose is threefold:

- i. to minimize the risk to occupants some of who may have to remain in the building for some time whilst evacuation proceeds, if the building is a large one.
- ii. to reduce the risk of firefighters who may be engaged on search or rescue operations.
- iii. to reduce the danger to people in the vicinity of the building who might be hurt by falling debris or as a result of the impact of the collapsing structure on other buildings.

2. Columns

The function of a column is to carry the part of the weight of the building where an internal wall would interfere with the designed use or where a large open space is needed. A column is often designed to withstand only vertical loads and

any eccentric loading greatly increases the stress and will overturn any column not rigidly fixed at its foot.

3. Beams

The primary function of a structural beam is to support an applied load. A simple beam is one of short span supported at each end. A continuous beam is used in

longer spans and supported on a series of columns. In this way a greater load can be carried than by using a series of simple beams.

4. Floors

a. **General**

In all except single-storey buildings, floors are a principal structural element and vary greatly according to the design of the structure. Floors can be regarded as being composed of three (3) parts.

- i. the actual loadbearing members
- ii. the upper surface or finish of the floor and
- iii. the lower surface of ceiling of the compartment below.

OTHER ELEMENTS OF STRUCTURE

1. Non-load-bearing Partition Walls

The term “partition” or “partition wall” is used when referred to walls whose sole function is the division of a space within a building into separate rooms.

2. Stairways

A Stair is a number of steps leading from one level to another, the function of

which is to provide a means of circulation and communication between the various levels within a building. Its function in buildings is twofold

:

- (i) That of normal everyday access from floor to floor.
- (ii) That of escape from upper floors in the event of fire.

Functional requirements

In order to satisfactorily perform this twofold function the stair must fulfill certain requirements, which are the provision of adequate:

- (i) Strength and stability
- (ii) Fire resistance
- (iii) Sound insulation

Stairs used as escape route or part thereof must maintain some basic features:

- (i) Constructed from non-combustible materials
- (ii) Stairway protected by a fire enclosure
- (iii) Separated from the main floor area by a set or sets of self-closing fire-resisting doors.
- (iv) Limitations to height of riser, length of tread and handrail requirement base based upon the use of the building.
- (v) All riser height must be equal throughout the rise of the stair.
- (vi) The head of the stair to be ventilated to prevent mushrooming.

In all cases stairways and ramps, which form part of the structure of the building, are required to provide a safe passage for users. In many cases they may represent the only way out of the building in the event of a fire.

The requirements are, therefore, that they should be made from materials of limited combustibility and be continuous leading, ultimately, to a place of safety. This applies whether the stairway is internal or external.

3. Doors and Shutters

A door is a screen used to seal an opening in a building or between rooms within a building used mainly for entrance/exit. Doors may be classified either by their function, method of construction or their position in the building. By position you have external and internal doors.

- a. Hinged doors
- b. Swing doors
- c. Revolving doors

- d. Sliding doors
- e. Folding doors
- f. Cantilever doors
- g. Roller shutters

In many gates and doors of industrial premises, a small door, often referred to as a 'wicket door', may be inset, e.g. a hinged door set in a sliding gate.

5. Windows

Windows are openings in walls with the primary function being to provide a means for the admission of natural daylight to the interior of the building. Windows may also be used to provide the ventilation necessary for buildings by regulation and codes.

6. Roofs

It has been stated, "a roof is a structure which surmounts a building to keep out the weather and may be flat, pitched or curved". Whether this could be applied to some modern buildings with roofs made of fabric, glass, plastics, tubing, cables etc. and which are suspended, cantilevered, sometimes geodetic, frequently braced and, occasionally inflated is problematical. Many single-storey industrial buildings appear to carry the walls straight over into the roof and consist of polymerized insulation sandwiched between metal cladding. Others include large areas of glass or polycarbonate, which, again, covers both walls and roof.

Behaviour Of Roofs and Roofing Material In Fire

General

Roof coverage is, in general, non-combustible or, at least, not readily combustible (an exception being thatch) so a roof is not normally vulnerable to fire from an external source. Generally it is the way roofs are built rather than the material used that causes difficulties for firefighters.

BUILDING DESIGN

Fire protection

Fire Protection is that part of building construction that is concerned with providing defence against an outbreak of fire with the objective of delaying its development, restricting its spread, and completely extinguishing it. The aim of fire protection is to ensure personal safety and minimize damage to property. Fire protection is broken down into broad areas:

(i) Passive Defence : Which is the use of design/planning techniques, structural measures, and the choice and use of materials that control the development and spread of fire into and out of a building and to provide for the safety and escape of the occupants. Passive defence covers Structural, Design, and Materials.

(ii) Active Defence : is the use of system, Equipment, Appliances and other aids for the early detection and which assists with the complete extinguishing of the fire. Active Defence covers Detection, fire Fighting and Alarm.

Where fire is concerned, the most important contents of a building are its occupants and it is their protection, which should be uppermost in the mind of the architect. In all buildings or structures, the time taken for the occupants to reach a place of safety is important. To do this it is necessary to ensure that, if a fire breaks out in one section, its effect on other sections is minimal for as long as possible to enable people to get out safely

COMPARTMENTALISATION

1. Introduction

To prevent the spread of fire within buildings, provisions are made to sub-divide the buildings into compartments with restricted floor or cubic capacity. This is done by means of compartment walls and require fire resistance. The object is two-fold:

- a. to prevent fire spread which could trap occupants to the building and
- b. to reduce the chance of fires becoming large, on the basis that large fires are more dangerous not only to occupants but to people in the vicinity of the building.

2. Degree of Sub-Division

This depends on:

- a. the use of the building, which affects the potential for fires and the severity of fires, as well as the ease of evacuation;
- b. the height of the top of the storey of the building which is an indication of the ease of evacuation and the ability of the fire service to intervene effectively; and
- c. the availability of a sprinkler system, which affects the growth rate of the fire and may suppress it altogether.

3. Requirements

Every compartment wall and compartment floor should

- a. form a complete barrier to fire between the compartments they separate;

- b. have the appropriate fire resistance according to their uses group and
- c. where needed (together with any beam or column which forms part of the wall, and any structure which carries it) be constructed of materials made of limited combustibility
- d. a compartment wall, which is used to form a specific part of a building should run the full height of the building in the same continuous vertical plane. It should be taken up above the roof or the roof should resist fire penetration and spread.
- e. where a compartment wall or floor meets another compartment wall, or an external wall separating wall or protected shaft, they should be bonded together or fire stopped.
- f. spaces that connect compartment, such as stairways and service shafts, need to be preferred to restrict fire spread between the compartments, and they are termed protected shafts.

3. Permitted Openings

There must, obviously, be some communication between compartment and the Regulations restrict these and set standards of protection required in various appendices to the Approved Document.

a. Openings

Any opening in a wall, which is common to two or more buildings, should be limited to those for;

- i. a door, which is needed to provide a means of escape in case of fire and has the same fire resistance as that required for the wall and is fitted in accordance with the relevant provisions.
- ii. the passage of a pipe, which meets the relevant provisions.

FIRE SPREAD

1. Definitions, Internal

- Ceiling overhead - a part of a building, which encloses and is exposed in a room or circulation space.
- Roof - an enclosed space in a building that is not an enclosed circulation space. (Thus the term includes not only conventional rooms but also cupboards that are not fitted and large spaces such as warehouses and auditoria).