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Possibilities for Timber Structure in Stadia – Fire Engineering Approach

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ABSTRACT: The demand for mass timber in construction is increasing as society seeks to build with more sustainable materials. As a result, there has been an increase in the number of mass timber buildings with these largely being commercial, education, and residential use. Although a few examples exist globally, an area where mass timber is yet to be used at scale is in stadia design. Stadia are typically large-scale structures where utilizing mass timber construction could provide sustainability and aesthetic benefits for designers. There is a perception that timber construction represents an unmanageable fire risk due to its combustible nature. In the context of stadia this is driven by catastrophic historic fires, such as the Bradford City Stadium Fire in the United Kingdom. As a result of such events, current safety and design standards introduce additional constraints for stadia where combustible structure is used which is inhibiting the uptake of extensive mass timber in designs. This paper explores the possibilities for mass timber in stadia and proposes a design methodology to allow mass timber construction to be used as part of the wider structure of stadia while still satisfying the intent of globally recognized design guidance.

KEYWORDS: Mass Timber, Stadia, Fire Engineering, Design Approach

1 – INTRODUCTION

As the demand for mass timber buildings has accelerated globally there has yet to be a rapid uptake of using mass timber at scale in the design of stadia. Stadia are large-scale structures where utilizing mass timber construction could provide large sustainability and aesthetic benefits for designers and is therefore an area where its use should be explored. Timber in its many forms has been used for large arenas, halls and long-span structures for many decades and hence is a material suited for the structural and architectural form of a grandstand. One potential reason behind the slow uptake of mass timber stadia is the restrictive nature of the Guide to Safety at Sports Grounds, (commonly known as the 'Green Guide') [1] one of the few guidance documents specifically written for the fire safety of stadia, and places significant limits on the use of a combustible structure. The Green Guide is used internationally for stadia design including in Australia, New Zealand, Singapore and the United Kingdom. This paper provides background to the Green Guide, how mass timber can be used within a stadia project and proposes a design approach for utilising mass timber.

2 - BACKGROUND

2.1 Fire Safety Objectives

Fire safety strategies are complex for stadia as this occupancy typically involves a large number of occupants who are likely to be unfamiliar with their environment and the egress routes within the building. The Green Guide states that the primary objective of fire safety in stadia is to *prevent the outbreak of fire, by taking steps to reduce the risk of fire and by providing and maintaining the appropriate means of both active and passive fire protection*. Other objectives include detecting fire at an early stage, reducing fire spread, delaying structural collapse and also to provide adequate escape routes for occupants. These objectives are similar to other building regulations and codes, though are more focussed for stadia.

2.2 Local Codes and Standards

It should be noted that the Green Guide is a guidance document. Its use within the context of the jurisdiction in which it is being applied should be considered by the design team as local codes and standards may dictate different and more onerous requirements with regards to materiality of building construction as well as the fire

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protection and safety measures required. These requirements may take precedence over the guidance in the Green Guide.

Some countries building codes recognise stadia as a separate building type and provide design guidance accordingly. However, others recognise stadia as enclosed buildings and apply design guidance commensurate to this type of structure which can often be overly onerous when considering that stadia are often open and naturally ventilated spaces where a fire would behave very differently to one in an enclosed compartment. This is apparent when comparing the approaches in England and Australia. In England the principal guidance document followed is *Approved Document B Volume 2: Fire Safety* [2] which defines stadia as assembly buildings and specifies that the guidance within the 'Green Guide' should be adhered to as part of the design. Conversely in Australia, under the *National Construction Code Building Code of Australia 2022* [3] stadia are required to comply with the same fire safety requirements as if they are a large, enclosed building (unless they only have a single tier of seating in which case dispensations apply). This includes the definition on Type of Construction which if meeting the criteria for Type A, places restrictions on the use of mass timber construction.

2.3 Mass Timber Structures

Engineered mass timber construction is a combustible material and therefore, when used for the structure of a building, needs to be considered in the context of the fire strategy objectives described above. Where large quantities of combustible material are proposed, the consequence of a fire can be changed due to increased fire severity (intensity and/or duration). This has been evidenced by fire experiments globally that have looked to quantify the impact of exposed mass timber construction within fire compartments based on the total heat release rate of a fire and rate of fire spread [4]. In a practical sense, increased fire severity can impact on availability of egress routes for evacuation and the ability of the structure to withstand a fire for its assigned fire resistance period. Firefighting can also be impacted. Designers therefore need to understand how the choice of mass timber will change the fire strategy for a building compared with other non-combustible materials, and what mitigation measures need to be included.

Traditionally many stadia, particularly smaller stands, were constructed using lightweight timber frame construction. However, the use of this material has been phased out following historic fires in stadia using this type of construction (see Fig 1).

Whilst inherently self-evident, mass timber can be engineered to have a longer inherent fire resistance period when compared to lightweight timber frame construction, and the difference between mass timber and lightweight timber framing is important for the design of stadia. This inherent fire resistance of mass timber greatly reduces the risk of localised structural failure, when compared to previously constructed timber framed grandstand and tiered seating structures that have utilised light frame.

The level of inherent fire resistance when utilising mass timber can be influenced by the designer through the oversizing of structural cross-sections allowing for a sacrificial layer under fire conditions. Cross sections can be sized using methodologies outlined in standards such as AS1720.4 and EN 1995-1-2 based on standard fire exposure. Refer to Fig 1 for a concept design utilising mass timber elements with larger cross sections.

As many countries commit to ambitious sustainability targets, mass timber at scale presents an opportunity for designers to help meet project specific targets for embodied carbon. Additionally, exposed mass timber is an aesthetically pleasing material which can help architects and clients achieve their design ambitions.


Figure 1. Mass Timber Framed Stadia Concept © Zaha Hadid Architects (left) vs Lightweight timber frame grandstand © Brett Hartwig/InDaily (right)

3. Impact of the Bradford City Stadium Fire

On the 11th of May 1985 the Valley Parade Stadium in Bradford, United Kingdom was involved in a major fire that resulted in the catastrophic loss of 56 lives and injuring a further 265 spectators. The Valley Parade Stadium was constructed of combustible materials including light timber frame and a bitumen roof.

The fire is believed to have started by a discarded cigarette which fell through a crack into the void directly below the stand seating. The fire developed rapidly, taking less than four minutes for the stand to be become engulfed in flames. It was later identified that large quantities of rubbish had accumulated within this void and warnings of this hazard were ignored. The accumulation of rubbish almost definitely played a role in the development of the fire. The combustible nature of the structure allowed the fire to spread rapidly through the stand (see Fig 2).

This catastrophe led to rigid new safety standards in UK stadiums. This included the banning of new grandstands constructed with timber. It was also a catalyst for the substantial redevelopment and the modernisation of many football grounds in the UK. These changes have carried through to current safety guidance and, of particular relevance to this paper, the Green Guide.

Figure 2. Bradford City Valley Parade Stadium Fire 1985

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4 – Green Guide Design Approach

The Green Guide is an internationally recognised document used in the licensing, design and planning and the safety management and operations of sports grounds. It is one of the few guidance documents that addresses occupant evacuation and structure for stadia and is therefore a popular document for fire engineers to use.

4.1 'Green Guide' Fire Risk

When following the Green Guide for the design of stadia, it is required to categorise the fire risk ('*low*', '*medium*' or '*high'*) based on defined criteria. Where combustible structural elements are present, a 'high' fire risk category is likely to be needed as '*There are structural elements that could promote the spread of fire, heat and smoke'*. This has impacts on the required design criteria, mainly the requirement to provide adequate escape routes to allow all occupants within the seating bowl to reach a '*place of reasonable safety*' within 2.5 minutes, which is a very onerous requirement. In comparison the maximum egress times for a '*low*' and '*medium*' risk profile are 8 minutes and 6 minutes respectively.

The much-reduced required evacuation time for *'high'* risk profiles impacts significantly on the bowl geometry, specifically on the required number of vomitories which would reduce the total seat numbers as well as affect sightlines to the playing surface.

Designers calculate egress times using simplified flow calculations as documented in the Green Guide.

4.2 'Green Guide' Place of Reasonable Safety

As outline above, the Green Guide sets a required time to reach a '*place of reasonable safety*'. This is defined as *a place or places of reasonable, or relative safety where for a limited period of time, people will have some protection from the effects of fire and smoke or other threats, before continuing their escape to a place of safety.*

The 'Green Guide considers the different areas within a stadium as 'zones' as depicted in Figure 3.

- Zone 1 - The pitch
  Zone 2 - The viewing accommodation (often defied as the bowl)
- Zone 3 - Internal concourses, vomitories and hospitality areas
- Zone 4 – Outer Circulation zone (outside of the stadia)
- Zone 5 – Buffer zone used for the public to gather before entry into the ticketed area.
- External Zone – Public realm encompassing the main pedestrian and vehicle routes to the venue.

Note: Some smaller stadia may not have Zone 4 and Zone 5.

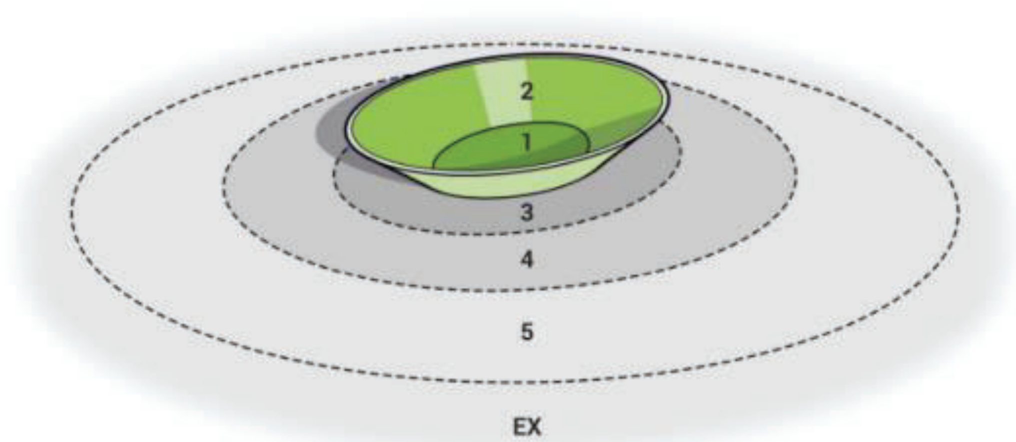

Figure 3. Green Guide Stadia Zones

For stadia design when following the Green Guide, Zones 3 and 4 are typically taken as the place of reasonable safety if it can be demonstrated that occupants are no longer in danger from the effects of fire or other threats. This is often achieved by fire separating areas of higher risk from the concourse. When designing with mass timber the additional hazard of exposed timber in the concourse should be considered when assessing if this is a suitable place of reasonable safety. This is further

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discussed as part of the proposed methodology in Section 5.

5 – Proposed Mass Timber Design Approach

This section documents a proposed design approach for incorporating mass timber into stadia designs, specifically highlighting key aspects that designers should take into consideration.

5.1 Stadia Size

When considering the use of timber in stadia design a key consideration should be the size and scale of the stadia. As is the case with other building types (for example low-rise vs high-rise towers) the size and scale of a building directly influences the consequence in the event of a fire as a result of the number of occupants that need to be evacuated, the travel time to a place of ultimate safety, the need for internal fire-fighting and the need for the structure to retain its integrity for an increased duration of time. As a result of these design objectives, a larger building requires more fire safety systems to reduce the probability of a fire that could compromise the fire safety goals occurring.

The discussion regarding the use of mass timber construction should therefore consider the above factors at the outset of a project to determine if the increased hazard posed by combustible construction is appropriate. The scale of stadia should also influence the safety features required. For example, small single level grandstands which are accessed from ground level are perfectly suited for mass timber. In comparison, the integration of timber into large stadia where there are multiple seating and concourse levels will be more challenging and require more robust safety measures to support.

5.2 Structural Considerations

This paper primarily addresses the approach to stadia design with engineered mass timber from a fire safety and engineering perspective. It is however important to not consider fire safety in isolation as there are many drivers for the use of mass timber in stadia projects. The choice of material is primarily driven by the efficiency of the structure and the overall structural design and architectural objectives will typically govern if mass timber is an appropriate choice.

Structural engineers face a number of challenges when utilising mass timber in stadia design, such as occupant induced vibrations, impact of winds, seismic resistance and durability. These factors need to be considered for other materials, though they may play a more significant role where mass timber is more proposed.

Multi-tiered stadia are often designed as cantilevered structures supporting the tiered seating. Mass Timber may be used for the load-bearing structure, as girders and columns, and can also be used as planks to support the seating. Mass timber can also form part or all of the roof structure. For larger stadia, a hybrid structure would be expected to form the most efficient structure, where mass timber such as glulam is used for structural members in combination with steel or concrete, supporting CLT as floors.

Directly impacted by the structural design is the sustainability outcomes of the project, specifically regarding embodied carbon associated with the structure. From experience hybrid structures (in combination with concrete or steel) often perform better from an embodied carbon perspective.

5.3 Stadia Roof Design

The roof is often an architectural statement for new stadia and the use of mass timber as part of the roof is a location that makes the most sense, for both structures and fire safety.

Roof structures in stadia typically have much reduced or no fire resistance requirements because they are not supporting a floor and building codes generally provide concessions for roof structures. As a result, the engineering design for the structure can become much simpler if there is no requirement for fire resistance. This makes mass timber an attractive option, given complexities for fire rating of connections may not be needed and the use of tension members (typically steel) with the mass timber can make for an efficient structure. However, it should be noted that roofs often provide support to ancillary elements in stadia such as lighting rigs, screens and cameras which could cause serious damage should they fall from high level. In line with the Green Guide recommendation, designers should undertake a risk assessment to establish if any fire resistance performance is required for the roof, or parts of the roof where there are occupiable spaces below, or potentially dangerous fixtures above occupants.

There are many examples globally where the stadia primary structural system is non-combustible with timber utilised to support the roof only. An example of this is the Japan National Stadium in Tokyo where the roof has a truss structure which combines structural steel and glulam beams (see Figure 4).

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A further example of this is the Hayward Field track and field stadium in Oregon, which features large timber arches that support the roof. Excitingly, there are stadia projects in design that will also look to incorporate timber to support the roof. Cox Architects have unveiled a concept design for the new Mac Point stadium in Hobart, Australia which, if constructed, will feature the world's largest timber roofed stadium where a dome is proposed across the playing surface. [5]. These examples are shown in Figure 5.

Figure 4. Japan National Stadium in Tokyo utilising timber beam as part of the roof structure © Kengo Kuma Associates

Figure 5. Hayward Park in Oregon (Left) © CannonDesign and Proposed Mac Point Stadium in Hobart (Right) © Cox Architects

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5.4 Fire Engineering Design Approach

As outlined in Section 5.3, there are examples of stadia globally where engineered mass timber has been used as part of the roof structure. It has however not been used at scale as part of the wider structural system in stadia.

As part of active project work where architects are proposing mass timber, Arup have reviewed a number of stadia designed globally which utilise timber structure as well as other combustible materials such as polymer membranes which are often used for roofs (such as polytetrafluoroethylene). Following this review an initial approach has been explored to facilitate mass timber in the stadia structure without triggering the more onerous requirements for '*high*' fire risk. '*Medium*' fire risk is defined in the Green Guide as being where the following is achieved:

1. *The risk of fire spreading is low;*
2. *Should a fire occur it is likely to be confined to a room or its place of origin;*
3. *There is in place an effective fire suppression or containment system.*

The above needs to be considered in the context that mass timber behaves very differently to lightweight timber frame structures which is understood to have been the source of the combustible elements clause outlined for '*high*' fire risk. Adopting a holistic approach to consider the hazard posed by mass timber in the context of the risk classification criteria in the Green Guide can provide design teams with more flexibility.

This section outlines the different measures and design aspects that should be considered when looking to apply mass timber is stadia to facilitate this design approach. It is considered that the above criteria for '*medium*' risk can be satisfied for a design with large quantities of mass timber which allows for a longer evacuation time to be adopted.

It is intended that designers consider the below measures as a toolbox of design elements that could be employed in their fire strategy design to meet the fire safety objectives and design goals.

5.4.1 Locations of Exposed Mass Timber

At the outset of the design process, the key questions that should be asked is where does the use of timber make most sense? This should be considered from a fire safety perspective but also from a structural design and sustainability perspective as described in Section 5.2.

From a fire safety perspective, it makes most sense to use mass timber in areas of lower fire risk to limit the probability of the timber becoming involved in fire. This may work best from an architectural perspective as often the front of house spectator areas is where there is the least fuel load but also the greater desire to have exposed timber. Exposed mass timber in higher risk areas such as back of house storerooms, plant rooms and areas with cooking facilities should be avoided due to increased hazard. In these areas alternative non-combustible construction materials can be used or the timber structure can be encapsulated using a tested fire rated product which will prevent the timber becoming involved in fire for a defined period of time. Such areas may also include automatic sprinkler systems.

Suitable selection of the locations of exposed timber is an important part of the design framework and sets the foundations from which further fire safety measures should be selected.

5.4.2 Place of Reasonable Safety

As described in Section 4.2, a key step in applying the Green Guide to projects is defining the '*place of reasonable safety'* where evacuation times are measured to. In conventional stadia design the concourse (Zone 3) is typically considered to be a place of reasonable safety as it is often a fire sterile space as a result of concrete and steel structure alongside limited furnishings which could become involved in fire. However, changes in usage of the concourse over time and addition of higher fire loads in some stadia have occurred which have made the assumption of a "sterile safe" problematic. This is an important consideration for future stadia management.

Fire separation, using fire rated shutters or other systems, is often provided to retail, food and beverage stores and kiosks further reducing the fire risk if sprinkler protection is not included. But sprinklers may also be part of the design solution.

The impact of mass timber on the place of reasonable safety should be considered by designers. The consequence of large quantities of combustible construction becoming involved in fire means that it may not be appropriate to consider the concourse as a the '*place of reasonable safety*'. If this is deemed to be the case, then the mass timber can be encapsulated, or Zone 4 (outer circulation zone outside the stadia) should be considered as the point tot which evacuation times are

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measured. This will require a suitable number of evacuation paths (stairs / ramps / doors / gates to outside) to be provided, allowing for the designer to demonstrate via flow calculations that the required egress time can be achieved. Designers should also consider if extensive timber on egress paths means that an exit should be discounted when undertaking egress calculations in accordance with the Guide, though from a fire hazard viewpoint, retail stores are a greater fire ignition source and fire load, than a mass timber structure. The fire hazard caused by the mass timber structure does need to be considered in relation to the other combustible fuels that will be in concourse areas.

The Green Guide does not differentiate egress based on mobility impairments. The defined '*place of reasonable safety*' therefore needs to be considered when evaluating the egress provisions in place for mobility impaired occupants who may be unable to self-evacuate using stairs or ramps on egress paths. If the concourse is no longer considered the 'place of reasonable safety' then the design should either:

- Accommodate refuge locations associated with evacuation lifts that are separated from the concourse by fire rated construction providing a 'place of relative safety for mobility impaired occupants', or
- Provide a suitable number of evacuation lifts for the number of mobility impaired occupants expected that allows for them to reach Zone 4 in the same time period as other spectators. Designers should undertake egress calculations that consider lift cycle times to demonstrate that this can be achieved.

Any management procedures to support the evacuation of these occupants should be factored into the stadia fire safety management plan.

5.4.3 Fire Compartmentation

Fire compartmentation is an important measure in limiting the fire risk in stadia and thereby achieving the criteria for '*medium*' risk. It is important that higher risk areas in terms of both fuel load and ignition risks are separated from critical areas including egress paths. The Green Guide requires that retail stores or catering outlets incorporating deep fat fryers or hot food cooking facilities should be separated from spectator accommodation by fire resistant construction achieving a performance of at least 30 minutes. This is often achieved by fire rated roller shutter operated manually or by fusible link. This approach is often considered differently when sprinkler protection is installed, with the design relying on active suppression, rather than operable passive protection. Both approaches are reasonable.

When considering spectator accommodation with timber linings designers should consider if separation achieving a fire resistance period of 30 minutes is sufficient or should this be upgraded to a higher level to account for the increased consequence of fire spread.

The Green Guide also requires areas of viewing accommodation in the bowl to be separated from adjacent areas and voids by construction achieving at least a 30-minute fire resistance period. This is often achieved by the build-up of the bowl construction providing fire separation to areas beneath the seating. The Guide specifically requires designers to assess the risk of fire spread from hospitality areas that may open directly into the bowl. The need for any fire separation is sometimes designed out through a fire risk assessment. This helps to support architectural designs with more open spaces and visual connections. This is often supported through the provision of fire suppression within the hospitality spaces.

It is important that designers consider the presence of timber within the hospitality areas in any risk assessment undertaken. The following suggested measures could be used to support designs.

- Fire separation between hospitality areas and the bowl (defined in Section 4.2) provided by fire rated glazing or automatic fire rated shutters. The level of fire resistance should be subject to the fire risk assessment.
- Incorporating fire suppression into the hospitality units as further discussed in Section 5.4.4.
- Limiting the level of exposed timber within the hospitality units using fire rated linings to encapsulate some or all of the mass timber construction, noting that this is often not desirable from an architectural perspective.

In order to achieve the criteria for a '*medium*' risk under the guide, other high-risk areas such as storage and plant room should be provided in standalone fire compartments to limit the risk of fire spread and increasing the likelihood that a fire will be contained in the location of origin.

5.4.4 Fire Suppression

The need for fire suppression in stadia is not mandated under the Green Guide and the need for this is typically dictated by local requirements or as a result of fire risk assessment outcomes undertaken by designers, or the desire for an architectural layout that is more open between floors and does not rely on operable fire shutters. Large-scale fire compartment tests with mass timber have demonstrated that suppression is an effective method of controlling fires despite the additional fuel load provided by the timber [6]. It is therefore recommended that fire suppression, generally in the form of automatic sprinklers, is provided in mass timber stadia, even where not required under local codes and standards. Any suppression system should be appropriate for the intended use, risk and location. The suppression system can have significant advantages in reducing fire hazards to retail stores, hospitality areas and back of house spaces where fire loads are higher and ignition risks are more prevalent. This recommendation assists in achieving the 'medium' risk criteria of confining a fire to its location of origin and that there is an effective suppression or containment system in place.

The designer should evaluate the areas that will require suppression and those where it is not. One area where there may be a desire to omit suppression may be the concourse due to the high ceiling height, any external openings to relieve heat and smoke, complexities with service routing and head locations, and these areas sitting outside the thermal envelope of the building resulting in additional features (such as trace heating to pipes) being required to support the sprinkler design. Risk assessments should be undertaken to establish a suitable design.

Note that as with any other mass timber building there may also be additional requirements from insurers and the need for suppression may also be driven by these requirements.

5.5.5 Natural Ventilation

When it comes to concourse design, these are either enclosed by the roof and external envelope or open to atmosphere (via openings in the envelope). The choice of concourse design from an architectural perspective can provide benefits from a fire strategy perspective. Where concourses are open to atmosphere. Natural ventilation is beneficial from a fire strategy perspective as it provides a means of venting smoke and reducing the temperatures in the event of a fire, when compared to enclosed spaces. This reduces the risk of larger fires developing and also assists in maintaining tenability in the concourse which is part of the egress path for spectators.

5.5.6 Timber Treatment

The Green Guide places restrictions on the surface spread of flame criteria that needs to be achieved for linings in spectator areas. Mass timber through its combustible nature is unable to achieve the criteria set out for these restrictions. Where mass timber construction is used and is exposed, treatments for mass timber can be applied that reduce the surface spread of flame across the material. Specifying coatings accordingly to limit the surface spread of flame is a method of meeting the requirements.

The design team should be cognisant of the design life of any treatment product proposed and the required period for reapplication. This requirement should be clear to the eventual operator of the stadia so that reapplication of coatings can be factored into the maintenance plan. Impregnation coatings that penetrate deep into the material substrate are typically not compatible with mass timber products such as glulam, laminated veneer lumber or CLT.

5.5.7 Fire Breaks

Fire spread through large open place spaces (i.e. the concourse) or external envelope of stadia can pose a risk from both an egress and fire-fighting perspective. From an egress perspective fire spread can result in multiple egress paths being discounted during a fire which will negatively impact egress times. From a fire-fighting perspective, fires spanning larger areas of the total structure are more complex to tackle. Fire spread becomes a greater hazard when the structure is combustible. Designers may therefore consider it necessary to incorporate breaks in the combustible structure to further limit the risk of fire spread. This can be achieved by using an alternative material in these locations or providing encapsulation of the timber structure. The location of egress paths (i.e. stairs and ramps) should be considered when selecting the location of fire breaks.

5.5.8 Voids

As evidenced by the Bradford City Stadium fire described in Section 3, voids pose a risk from a fire perspective due to the risk of debris accumulating in these voids. The Guide already provides mitigation measures to provide fire separation between voids and the seating areas based on this historic fire. However, in mass timber buildings voids pose an added challenge as where voids are lined with combustible material there is a greater risk of unseen fire spread. It is advisable that

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exposed timber is not included where voids are required and where ignition risks (electrical cables, etc) are also included.

5.5.9 Fire Safety Management

Fire safety management during operational use is an important measure in any building, but especially so in stadia with high numbers of occupants. It is therefore important that any management requirements set out in the developed fire strategy are achievable for the eventual operator and clearly set out in the fire strategy so that responsibilities are clear. The fire safety measures specific to mass timber structure will likely be around the limitation of fuel load and ignition risks due to the increased consequence of fire. The following may need to be considered by designers.

- Are any limitation required on any on pitch pyrotechnics (i.e. fireworks) due to the presence of mass timber in the roof structure and any further areas.
- Enhanced security measures to limit spectators bringing pyrotechnics such as flares and smoke bombs into the stadia.
- Ensuring fuel load controls in the concourse and other areas are strictly enforced to protect egress paths and support the conclusions of any fire risk assessments.

If possible, design teams should work through management procedures with the eventual operator during the design process to allow for a collaborative development of the fire safety management plan and flexibility for potential functional or other operational changes into the future.

5 – Conclusion

An initial design approach to facilitate a mass timber structure in stadia design within the context of the Green Guide has been developed. The aim has been to not trigger the requirement for more onerous evacuation times for 'high' risk. Adopting a holistic approach to consider the fire hazard posed by mass timber in the context of the risk classification criteria in the Green Guide can provide design teams with more flexibility and consideration of the relative combustible fuel loads that are present in a modern stadium is important. The inclusion of the mass timber structure needs to be viewed in context of the ignition hazards and fire loads within the typical retail stores, hospitality areas and back of house spaces. Designers should consider each stadia project on its own merits and incorporate a combination of design measures commensurate to the hazards and risks to achieve key fire safety objectives.

6 – REFERENCES

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