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Design Note No. DN01E

Project Camden Road, London **Date** 10th November 2020

Subject Fire Safety Overview

1.0 DOCUMENT CONTROL

Issue	Date	Description	Author	Reviewed
-	28/11/19	Initial issue	BW	BH
A	27/04/20	Including design updates during Stage 3	BW	BH
B	30/04/20	Including design team comments	BW	BH
C	18/05/20	Including client discussions & feedback	BW	BH
D	15/06/20	Updated to address evacuation comments	BW	BH
E	10/11/20	Tender issue updates	BW	BH

Note: All updates since the previous issue are highlighted with a vertical line in the right hand margin.

2.0 INTRODUCTION

BWC Fire Limited (BWC) has been appointed to produce the fire strategy for development of the site known as Camden Road in London.

This report, DN01, was originally produced during Stage 2 with this Issue A/B update including the development of those original principles to reflect the designs progression. Issue E of this report includes feedback from the Camden Service with a view to mitigating potential concerns on the defend in place evacuation philosophy experienced on other sites and also updates leading towards tender. The fire alarm systems have therefore been updated to allow flexibility should the philosophy be changed at a future date.

These fire strategy principles will be based on the guidance in Approved Document B (ADB) to the Building Regulations, August 2019 Edition (including the May 2020 amendments) as well as other relevant guidance, such as British Standard BS5839 Part 6.

Following the client briefing it was confirmed that the accommodation is intended for homeless families and therefore the occupants are generally a stable family unit with few support needs beyond accommodation. The families tend to have a higher frequency of single parents however it is not expected that the occupants would need secondary assistance to evacuate, would pose a higher / unusual fire risk in their own right (e.g. have a history of arson etc), or would expect to have unusual responses to a fire alarm event. Further to this the building management assess the needs of the families prior to providing accommodation and allocate according to their needs and risks. Occupants whom are known to have prior history of issues (e.g. hoarding etc) are also closely monitored with site management undertaking regular inspections to prevent issues escalating.

Further to the above families will generally be given accommodation on a period between six months up to two years with the accommodation being given via a planned process, therefore it is not short notice accommodation. Given this background it is proposed that the building is more appropriate to be considered as a general purpose apartment block which includes some onsite facilities management services rather than a hostel building. On this basis the building has been considered under Purpose Group 1(a) of Approved Document B. It should be noted that this designation is subject to discussion and agreement with Building Control during Building Regulations stages.

3.0 FIRE STRATEGY PRINCIPLES

The information summarised in the table below reflects the fire safety aspects of Building Regulations that are applicable to the building when treated as an apartment building to current standards.

Design Item	Recommendations
Evacuation Philosophy	• Based on the external walkway access, extent of the compartmentation proposed plus the building use the building has been treated as an apartment building. Given this a defend in place evacuation strategy has been adopted. • As noted in Section 2 the fire alarm systems will allow reprogramming to facilitate a simultaneous evacuation regime if desired at a later date.
Escape within the Apartments	• The units include inner sleeping rooms and will adopt the principles for open plan apartments discussed in BS9991. On this basis each apartment will include residential sprinklers and L1 standard fire alarm and detection systems. The cooking hobs should be remote from the escape routes and are proposed as achieved where these are at least 1.8m away from the escape route. It should be noted that for any open plan unit that is greater than 8m by 4m in footprint (32sqm) with an open kitchen or layout which requires escape through the kitchen then these will require further justification by fire engineering. Currently virtually all apartments are less than 32sqm and therefore the basic prescriptive recommendations are being adopted. The only units which are larger than 32sqm have either enclosed kitchens through which escape is not required (enabling the open plan footprint to be increased up to 16m by 12m) or are wheelchair units which have traditional entrance hallways. • The cooking hob locations are not able to always be 1.8m away from the overall escape route due to the limit size of the studios. In these cases the hobs have been located to be as remote as possible within the space with all locations ensured to be at least 1.8m away from the final exit door (as this location will be where escaping occupants spend the longest amount of time as they open the door). A radiation analysis will also be provided to support these hob positions. • In all units the client has recommended that the cooking hobs include thermal cutout facilities to assist with minimising the potential for cooking fires. • In previous iterations of the layouts there were two units on the uppermost floor which included an inner-inner bedroom layout. These layouts have been amended to remove the inner-inner room configuration and maintain a similar open plan arrangement to those discussed above.
Escape within the Wheelchair Apartment	• At the rear of the block is a single ground level unit which is designated for potentially wheelchair bound occupants. As the occupants could be mobility impaired it is not considered reasonable for this unit to be open plan in a similar fashion to the other studios and therefore a more traditional layout has been adopted. In this case the bedroom and living space are self contained rooms which are each accessed from an entrance hallway. • In this case it is proposed that by adopting the same L1 fire alarm system and residential sprinklers throughout this unit then there it is not necessary for the internal entrance hallway within this apartment to be fire rated. This proposal is based on maintaining consistent facilities and principles across the scheme but also as the suppression assists with mitigating fire service access to this unit. • This unit may include a mobility scooter charging point. This point should not be located within the entrance hallway and instead should be located in the living room. With this living room charging location no further mitigation facilities are required for fire safety purposes.
Escape within the Common Areas	• The building is composed of ground plus five floors with the top floor being less than 18m high. At each floor the apartments are accessed from external access walkaways that connect onto a central single staircase. In this case the guidance in Section 7.3 of BS9991 is applicable as the current guidance for open balcony access routes, as detailed below: - The balconies will afford 30minutes fire resistance (both structurally and as compartment floors) - The walking surfaces will be imperforate - The facades adjacent to the balconies will afford 30minutes fire resistance up to a height of 1100mm. - The apartment doors will be FD30 self closing doors. - All balcony wall and ceiling finishes should be Class O rated. - The external balustrades should be imperforate however in this design it is proposed that the introduction of the sprinkler suppression mitigates the need for the imperforate construction (See further discussions in Appendix A).

Design Item	Recommendations
Escape within the Common Areas (Cont)	• The common staircase will be separated from the balconies and apartments by 60minutes fire resistance with FD30S self closing doors. • The common staircase will include a 1sqm manual remotely openable vent at the head of the staircase. No smoke detection is required to the common circulation areas of this building on the basis that these are external spaces. • The non-residential accommodation located at ground floor level are accessed from outside and are not linked by internal corridors to the residential escape routes. On this basis these accommodations can be considered in isolation to the residential escape routes. • The plant room at basement level is accessed directly from outside and is therefore considered acceptable based on the internal travel distances being limited to 9m to the nearest final exit. The exit doors should maintain a clear opening width of at least 750mm. As the plant room is accessed off the residential staircase it is recommended that this access should be via a basement lobby which is also provided with a 0.4sqm permanent natural vent that discharges to outside. The fire alarm system for the site will also cover the basement accommodations and be linked back to the staff office. It should be noted that further mitigation of this access may be needed depending on discussions with Building Control and therefore this access should be considered as a design risk. • As a hostel building the minimum staircase width for fire safety purposes would be 1000mm (all stair widths are measured between walls, providing the handrails do not protrude more than 100mm into the stair on each side). This width is sufficient to support the entire occupancy of the building in the event that a simultaneous evacuation was adopted at some point in the future. • Stair doors on upper floors should be a minimum of 750mm clear, generally final exits and any discharge corridors should maintain the clear widths of the staircases (1000mm). The direction of opening is not essential for escape (due to the low occupancy) however all doors on the ground floor final exit routes should open in the direction of escape. • The staircase discharge routes at ground floor should be maintained unobstructed and free of fire load. • Once occupants reach the ground level they can then either escape to the street via the main site entrance through the staff area or alternatively via the side external path. • Any access control devices fitted to the common escape route doors should be fitted with a manual override mechanism from the escape side of the door to enable occupants to escape without the need for a key in an emergency.
Escape Within Non-Residential Areas (Staff areas and community room)	• The maximum travel distances should not exceed 45m to the nearest storey or final exit where escape is possible in two directions, and 18m where escape is possible in one direction. These distances should be easily met based on the exit distribution. • In general each area will not serve more than 60 people and therefore each room will have sufficient exit width based on a single exit of 750mm clear width. It should be noted that further exits may be needed to satisfy travel distances. • As the accommodations are accessed from outside with respect to the apartment exit routes no further protection is needed beyond the 60minute fire resistance to party walls and floors. • All dead end corridors longer than 2m should be protected and enclosed in construction of at least 30 minutes fire resistance and FD30S self closing fire doors. • The staff areas have some inner rooms however these are considered acceptable on the basis of this space including coverage by the automatic fire alarm and detection system plus minimum 0.1sqm vision panels being included in the inner room access doors. • All doors on escape routes, including those from individual rooms should ideally open in the direction of escape. However it is mandatory for any exit door that is likely to be used by more than 60 people to open in the direction of escape.
Disabled Evacuation	• The non-residential accommodations have level access and egress therefore these areas do not require dedicated escape facilities for disabled occupants • In general disabled refuge facilities are not needed in residential accommodation so should not be provided in the residential common areas. This has been supported by the service teams confirmation that staff at this building will not generally be assisting

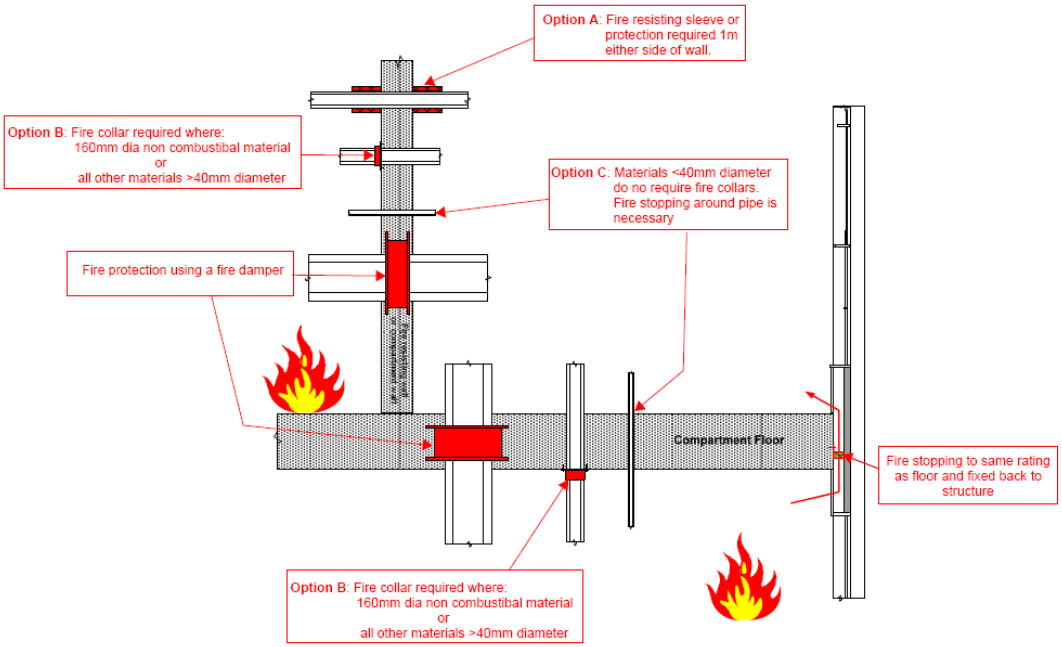
Design Item	Recommendations
Disabled Evacuation (Cont)	with evacuations and therefore emergency voice communications facilities are not considered to be a benefit. Notwithstanding this disabled refuge provisions and EVC provisions will need discussion and agreement with Building Control. • The Client has confirmed that the lifts will do not require additional enhancements with the exception that their power supplies will be from a dedicate spur from the distribution boards.
Fire alarm and detection system	• The building should be provided with an open protocol automatic fire alarm and detection system designed, installed and commissioned in accordance with the BS 5839 Part 1 to a minimum L1 standard. The L1 standard is due to there being a series of open plan units present. • Appropriate fire detection should be provided to all areas of the building. Manual call points should also be located by storey and final exits. It should be noted that further discussions with Building Control should be held with regards to the defend in place philosophy and details such as manual call point provisions. • The main fire alarm panel should be located by the main entrance. • Fire sounders should be provided to ensure a sound level of 75dbA at the bed head and 65dbA or 5dbA above background noise levels with the non-sleeping areas. • At this stage it is proposed that the evacuation philosophy for the building will be a defend in place philosophy. On this basis the activation of the fire alarm system will solely sound the alarm and evacuate the compartment of activation only. This evacuation premise is consistent with the apartment philosophy. Notwithstanding this on activation a management alert will also be sent to the staff office and associated warden call system. In addition the fire alarm system will also be linked to a remote monitoring service (e.g. BT Redcare or similar). • The lifts within the building should all ground automatically on the activation of the fire alarm system. Additionally all access controls to escape doors should be isolated on the activation of the fire alarm system. • The sprinkler system proposed throughout the building should on activation also trigger the fire alarm system. • Based on the defend in place philosophy any associated HVAC plant will only automatically shutdown on the activation of detection local to the plant rooms concerned and not on the general activation of the wider fire alarm system. It should be noted that there is no gas services to the building. • During the recent client meetings it has been requested that the fire alarm systems have the potential if desired to enable a simultaneous evacuation philosophy at some point in the future. It is for this reason why the L1 standard BS5839 Part 1 based system has been proposed. Subject to more detailed discussions with Building Control it may be necessary to alter the system designation to an L5 standard (i.e. a bespoke system) to facilitate this future requirement along with maintaining the defend in place premise of the current use (with respect to details such as manual call point facilities for example).
Sprinklers	• Due to the layouts of the apartments it is proposed that the apartments each include a residential sprinkler system that is designed to BS9251 and be of a minimum category 2 standard. The sprinklers should also be designed to include Table 2, footnote B requirements with respect to minimum design discharge density. • Notwithstanding the above the sprinklers are required throughout the building as a result of the changes to Approved Document B that were made in May 2020. To address this the sprinklers need extending to cover the entire non-residential accommodation in the building. This coverage will include the plant rooms. Given this the sprinklers will be increased to a Category 3 standard system.
Emergency Lighting	• This should be installed in accordance with Approved Document B and BS 5266 Part 1 recommendations.
Escape signage	• This should be installed in accordance with BS 5499: Part 1. • Fire door keep shut or keep locked signage should also be provided to all fire doors as applicable and outlined in Approved Document B.
Elements of Structure	• The building is less than 18m high therefore all elements of structure should afford 60minutes fire resistance. • Any elements which only support themselves and or a roof can be non-fire rated.
Compartmentation	• All apartments should have 60 minute fire resistant compartment walls with FD30 self closing front doors.

Design Item	Recommendations
Compartmentation (Cont)	• No fire resistance is proposed internal within each apartment however each will include L1 standard fire alarms systems and residential sprinklers. • All floors should be compartment floors with a fire resistance of 60minutes. • The common stair will be enclosed in 60 minutes fire resistance with FD30S self closing doors. This separation should apply to all parts of the staircase within 1.8m of the access balconies. • The building has an external balcony design where the apartments are accessed via balconies that are permanently open to outside and also in a dead ends. The design of the balconies will be in accordance with the guidance discussed in section 7.3 of BS9991, including: - The balcony will afford 30minutes fire resistance - The walking surface will be imperforate - The facades adjacent to the balconies will afford 30minutes fire resistance up to a height of 1100mm. - The apartment doors will be FD30 self closing doors. - All balcony wall and ceiling finishes should be Class O rated. • The lift shafts should have a fire resistance of 60minutes with FD30 landing doors. • Service risers should be constructed as continuous vertical protected shafts with a fire resistance of 60minutes with FD30 doors. No smoke seals or self closers are needed however the riser doors should be kept locked shut and signed as such. • In order to protect the staircase means of escape routes from a fire on the floor plates the wall construction within 1.8m of the staircase will be fire rated to 30 minutes • The staff areas, ancillary stores and community room will not require internal subdivision on the basis that each is less than 2000sqm. In this case each will have 60minutes fire separation from all adjoining accommodations. The residential sprinklers have also been extended to serve the staff areas and ancillary stores within the main building as mitigation of the forth coming changes to Approved Document B which are due to be released towards the end of May 2020. • As the plant room is accessed off the residential staircase it is recommended that this access should be via a basement lobby which is also provided with a 0.4sqm permanent natural vent that discharges to outside. It should be noted that further mitigation of this access may be needed depending on discussions with Building Control and therefore this access should be considered as a design risk.
Special Fire Risk Areas	• Plant and refuse rooms should achieve 60minutes fire resistance with FD30S self closing doors. • Any electrical sub-stations should be fully separated from the adjacent accommodation spaces by at least 30 minutes fire resisting construction, although these requirements are likely to be superseded by the electricity supplier's requirements, which are typical based on 4hours fire separation. • Refuse rooms accessed internally should be approached via a protected lobby which is provided with 0.2m^2 of natural ventilation direct to outside. • Cleaner cupboards, stores and utility rooms should be enclosed in 60 minutes fire resistance with FD30S self closing doors. • Any special fire hazard rooms (plant rooms) accessed off the internal circulation routes should be accessed via a 60minute fire resistant lobby which is provided with 0.4sqm of natural ventilation direct to outside.
Surface Linings	• All linings within the protected staircase and lobbies and escape corridors should be Class 0. • Any room with an area less than 4m^2 should have a Class 3 surface lining. • All linings in spaces with an area greater than 4m^2 should have a Class 1 lining. • All linings on escape routes (including circulation routes) should have a Class 0 rating.
Fire Stopping	• Ductwork passing through compartment/fire resistant walls will be either contained within fire resisting construction or provided with fire dampers. • The ductwork will be provided with fire and smoke dampers activated automatically on the activation of the building fire alarm and detection system. Fire and smoke dampers will be provided to ductwork which are installed in any of the following areas (unless they are contained within fire resisting construction throughout their route to fresh air): - Ductwork serving both escape routes and accommodation or; - Ductwork passing through both stairs, stair lobbies and accommodation or;

<table>
<tr><th>Design Item</th><th>Recommendations</th></tr>
<tr><td>Fire Stopping (Cont)</td><td>
- Ductwork passing through walls separating fire compartments.

• Any openings for services (exceeding the dimensions discussed in Table 9.1 of ADB, as shown below) breaching compartment walls or floors will be fire stopped (unless protected throughout their entire length with fire resisting material) in accordance with Section 9 of ADB. This is to prevent the passage of fire and to assist in retarding the movement of smoke. Joints between elements of structure that serve as barriers to fire will be fire stopped to prevent the passage of fire and smoke.

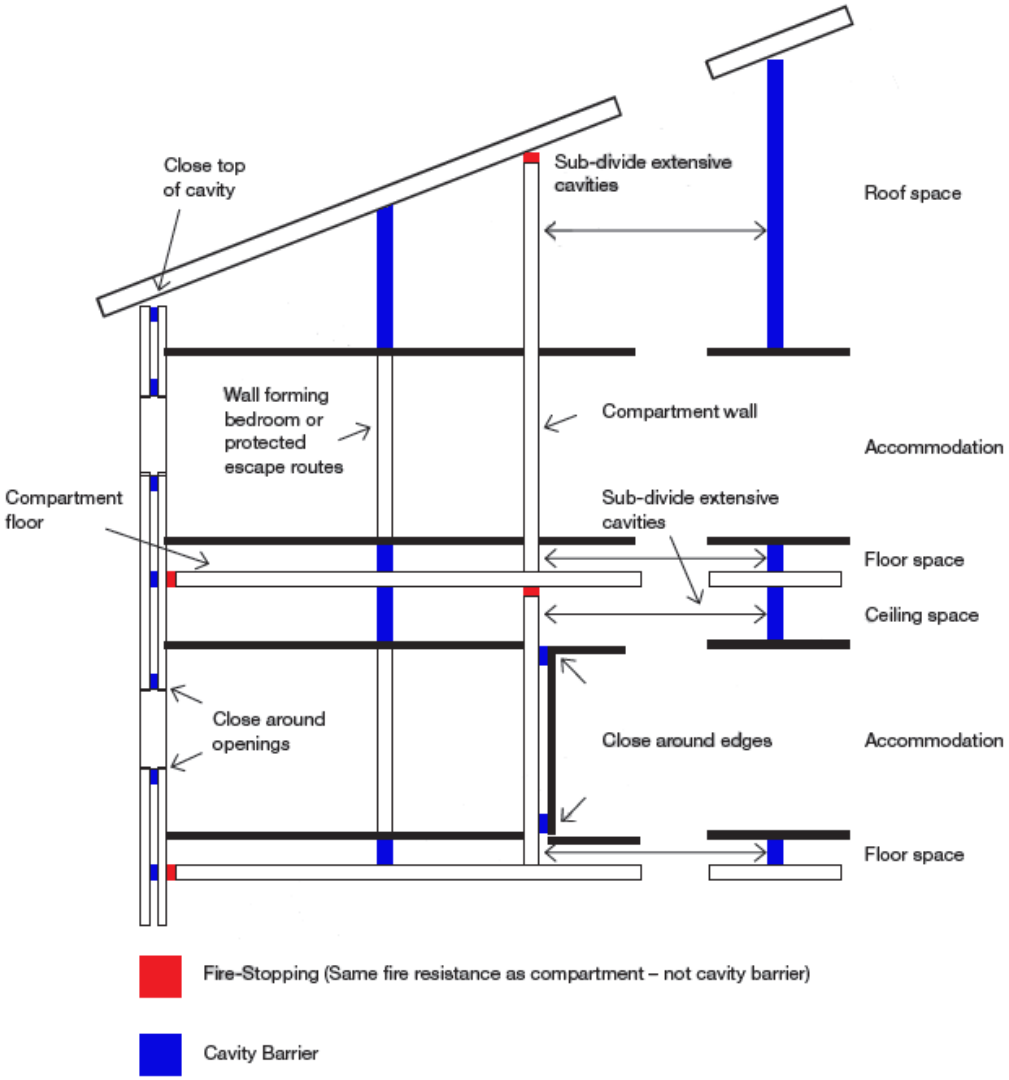
<table>
<tr><th rowspan="2">Situation</th><th colspan="3">Pipe material and maximum nominal internal diameter (mm)</th></tr>
<tr><th>(a) Non-combustible material</th><th>(b) Lead, Aluminium, aluminium alloy, UPVC, fibre cement</th><th>(c) Any other material</th></tr>
<tr><td>Structure (but not a wall separating buildings) enclosing a protected shaft which is not a staircase or a lift shaft</td><td>160</td><td>110</td><td>40</td></tr>
<tr><td>Compartment wall or Compartment floor between flats</td><td>160</td><td>160 (stake pipe)
110 (branch pipe)</td><td>40</td></tr>
<tr><td>Any other situation</td><td>160</td><td>40</td><td>40</td></tr>
</table>



</td></tr>
<tr><td>Cavity Barriers</td><td>
• Cavity barriers will be included in any large cavity with the potential for extensive unseen fire spread. The key areas that require cavity barriers are as follows:
- At the junction between an external cavity wall and a compartment wall that separates buildings; and at the top of such an external cavity wall.
- At the junction between an external cavity wall and every compartment floor and compartment wall.
- At the junction between a cavity wall and every compartment floor, compartment wall, or other wall or door assembly that forms a fire-resisting barrier.
- In a protected escape route, above and below any fire-resisting construction that is not carried full storey height.
- Where the corridor will be sub-divided to prevent fire or smoke affecting two alternative escape routes simultaneously.
- Within the void behind the external face of rainscreen cladding at every floor level, and on the line of compartment walls abutting the external wall of buildings
- At the edges of cavities (including around openings).

• In addition to the above locations cavity barrier are also required in cavities (including ceiling voids and under floor service voids) where the cavity exceeds 20m.

• The cavity barriers will provide a 30-minute fire rating (i.e. 30 minutes integrity and 15 minutes insulation). Any penetrations through the cavity barriers will be either;
- Fitted with a proprietary sealing system.
- Pipes of limited diameters that are sealed with fire-stopping, or sealed with sleeving of non-combustible pipe material.
</td></tr>
</table>

Design Item	Recommendations
Cavity Barriers (Cont)	• The specification of cavity barriers should not be confused with the specification of fire stopping between fire resisting elements, e.g. walls and floors, which should afford the same level of fire resistance as the fire resisting elements themselves. These principles and the general cavity barrier locations are indicated in the diagram below. 
Space Separation	• The works will need the external walls assessing for the purposes of space separation and external fire spread to neighbouring sites. Given the fire suppression and fire compartmentation between units it is unlikely that significant areas of the facades would need to be formally fire rated to mitigate external fire spread to neighbouring land. The exception to this are the two narrow end walls of the building and the rear wall of the community room. Where protected areas are required these will afford 60minutes fire resistance.
External Walls	• Strictly Approved Document B still prescriptively permits the inclusion of combustible materials in the external wall build ups however MHCLG subsequent guidance requires fire spread to be limited between units. Further to this the client has expressed the opinion that the external walls must not provide a route for fire spread. Given this it is proposed to adopt the same criteria as outlined in Approved Document B for buildings that are more than 18m in height. On this basis all materials used within the external walls should utilise Euroclass A1 or A2 rated materials.
Fire Service Access	• As the building is under 18m in height fire fighting shafts are not proposed however a dry rising water main will be provided to the common staircase. • All parts of the apartments should be covered within 45m hose distances from the dry rising main outlets within the common staircase. The dry main inlet should be located within 18m of the fire appliance parking positions with the inlet visible from the fire

Design Item	Recommendations
Fire Service Access (Cont)	appliance. The dry main inlet should be no more than a 18m horizontal distance from the vertical rise of the dry main pipe to comply with BS9990. • The dry main installation should comply with BS9990, this will include details such as dry main outlets being provided at all levels, including ground level. It has been identified by Camden that some installations have used HDPE pipework for underground sections of dry mains. Camden do not wish to see such materials used on this site unless independent test evidence demonstrates that any alternative design materials can achieve the pressure, robustness and durability requirements of BS9990. • The ground floor wheelchair unit may not be fully covered within 45m hose distances of the fire appliance parking position. It would be possible to have this covered within 45m of the ground floor dry riser outlet however this is a little contentious therefore it is proposed that the residential sprinkler system will also cover this unit to assist with the direct mitigation of the hose distances to this single unit. • The ground floor staff area and the community room are each less than 2000sqm and therefore each will be fully covered within a 45m hose distance from a fire appliance parking position. • Any access/security measures in and around the site (especially any bollards preventing vehicle access) should be bypass-able by the fire service. The details of the bypass arrangements should be developed and agreed with the fire service as applicable. • As no new compartment is being created that is larger than 280sqm there are no requirements to considered new fire hydrants within these works.
Smoke Clearance	• As an apartment building which has access via external walkways only requires limited smoke venting facilities which in this case would be a 1sqm natural remotely openable vent at the head of the common staircase. This vent should be operable via a manual switch located at ground floor level in the staircase. • The basement plant area should be provided with smoke clearance venting (unless the space is no more than 200sqm and no more than 3m below external ground level). Where the basement requires smoke clearance then this should be based on manually openable natural smoke vents (or break out panels such as pavement lights) that afford at least 2.5% of the basement floor area and be evenly distributed around the basement perimeter.
Power supplies	• In general most life safety systems in the building can function based on mains power, supported by battery backups (e.g. fire alarm systems, emergency lighting etc). However the sprinklers should be provided with a secondary power supply. • For basic Building Regulations purposes when treated as an apartment building then as highlighted earlier evacuation lifts and disabled refuges are not needed. However in this case the client wishes to some further resilience to the lifts to mitigate potential risks. On this basis the lifts in the building will not be provided with a secondary power supply but they will be powered by their own dedicated supply from the electrical distribution boards to minimise issues should a fire affect other areas of the building.
General Responsibilities	• Given the use and likely occupancy of the building, management procedures will assist in the prevention and control of fires and the evacuation of occupants, should this be necessary. • Good housekeeping standards will be enforced to ensure that the effectiveness of the fire safety provisions is not affected. • Maintenance procedures will be developed to ensure that all equipment and services within the building are able to operate effectively. • Other fire legislation requires effective management of all the buildings fire provision. A risk assessment will have to be carried out together with staff training, systems maintenance etc. All information gathered during the risk assessment and on an ongoing basis should be documented and available for inspection as required. • A management strategy will need to be developed for the building by the management team, and staff trained to include how disabled occupants will be evacuated in the event of a fire and identify key roles in ensuring they are assisted in a fire situation. • Where possible residents whom cannot use the staircases unaided will be located on the ground floor.

4.0 BUILDING CONTROL CLARIFICATION POINTS & NOTES

During the discussion and development of this design there were a few items relating to the fire strategy which will require further discussion and agreement with the Building Control Body in due course. This section of the report has been added to highlight those areas:

- Building Designation – The building is a form of hostel by basic prescriptive definition however the use and nature of the occupancy (being long term occupancy) results in the design team's view that the actual building is more akin to a general purpose apartment building. On this basis the fire strategy has been developed to this latter designation however this rationale is subject to agreement with Building Control.

- Open Plan Apartments – Following the above building designation the concept of the open plan layouts and hob positions will be subject to discussion and agreement with Building Control in due course.

- Basement Access – The basement plant room is accessed from a ventilated lobby off the staircase. This arrangement is proposed as being mitigated in part by the plant room fire alarm being linked to the staff office at ground floor plus the room being accessed by a ventilated lobby. Notwithstanding this the access is subject to discussions and agreement with Building Control.

- Disabled Egress Facilities – Currently the design is based on an apartment building concept with no full disabled refuge or EVC facilities. This proposal is consistent with current staff procedures in an emergency for Camden's similar buildings. Notwithstanding this Building Control may have different views due to the basic hostel prescriptive designation therefore this item needs to be discussed and agreed with Building Control.

5.0 REPORT LIMITATIONS

In preparing this report it has been assumed that detailed aspects of the design and construction will, unless stated otherwise in this report, be in accordance with the recommendations of the relevant Approved Documents to the Building Regulations, applicable British Standards and other relevant codes of practice.

This report relates only to statutory requirements associated with Building Regulations and the Regulatory Reform (Fire Safety) Order 2005. Additional fire safety measures necessary during construction/remedial works or for insurance, loss prevention or environmental protection purposes are not considered.

The terminology "will" or "will be" as used in this report represents the recommendation/understanding of BWC Fire Limited regarding the proposed design, construction or management of the premises. The validity of this report is reliant upon these items being implemented as described.

This report relates to a project that is subject to third party ratification and it must be ensured that the contents of this report are agreed with all the relevant approval bodies prior to implementation.

APPENDIX A – EXTERNAL DECK ACCESS BALUSTRADE ASSESSMENT

As discussed in the main report the apartments at each upper level are accessed from external balcony decks. The access balconies are generally designed in accordance with BS9991 however it has been proposed to deviate from this guidance with respect to the balustrade design. The BS9991 guidance recommends that the balustrades should be imperforate construction up to a height of 1100mm above deck level. In contrast the balustrades proposed are an open railing design which has been justified based on these apartments including residential sprinklers.

This assessment undertakes a comparison of the standard prescriptive guidance applied to this building layout (which would not have sprinklers) against the actual balustrade design based on the apartments being sprinklered. The rationale of the comparison is that the sprinklers reducing the severity of the fire products spilling onto the balconies offsets the potential greater smoke logging due to the open balustrade such that ultimately conditions on the balconies are similar or better in the actual design.

The assessment conducted in this appendix is based on a CFD modelling study.

The package used for this assessment was called Fire Dynamics Simulator (FDS) and was created and developed by the National Institute of Standards and Technology (NIST). The version used for this assessment was Version 6.

Fire Dynamics Simulator (FDS) is a computational fluid dynamics (CFD) model of fire-driven fluid flow. The software has been developed by NIST over a number of years and was originally intended to predict fire spread behaviour in warehouse racking systems. FDS's core program solves numerically a form of the Navier-Stokes equations appropriate for low-speed, thermally-driven flow with an emphasis on smoke and heat transport from fires. The formulation of the equations and the numerical algorithm are contained in the reference document, "Fire Dynamics Simulator (Version 6) – Technical Reference Guide". FDS is accompanied by a visualization package, Smokeview, which allows all the results from FDS to be viewed in a meaningful way. Both these pieces of software have been used in this report. Detailed descriptions of all FDS and Smokeview documentation and the programs themselves can be freely downloaded from the NIST Website (http://fire.nist.gov/fds/).

The models considered here incorporate a number of the in-built sub-models which form part of the FDS software. In this case the models included the inbuilt turbulence (Large Eddy Simulation, LES), radiation and combustion models. Each of these models is based on recognised scientific theory which have been developed and further validated by scientific research conducted by NIST.

The turbulence sub-model used for these simulations was the Large Eddy Simulation (LES) model which is the default turbulence approximation used as part of FDS's Hydrodynamic Model. FDS solves numerically a form of the Navier-Stokes equations appropriate for low speed, thermally-driven flow with an emphasis on smoke and heat transport from fires. The core algorithm is an explicit predictor-corrector scheme, second order accurate in space and time. Turbulence is treated by means of the Smagorinsky form of Large Eddy Simulation (LES).

Radiative heat transfer is included in the model via the solution of the radiation transport equation for a non-scattering gray gas. The radiation equation is solved using a technique similar to a finite volume method for convective transport, thus the name given to it is the Finite Volume Method (FVM). Using approximately 100 discrete angles, the finite volume solver requires about 15% of the total CPU time of a calculation, a modest cost given the complexity of radiation heat transfer. Water droplets can absorb thermal radiation. The absorption coefficients are based on Mie theory.

The combustion sub-model used has been developed as an integral part of the FDS software. FDS uses a mixture fraction combustion model. The mixture fraction is a conserved scalar quantity that is defined as the fraction of gas at a given point in the flow field that originated as fuel. The model assumes that combustion is mixing-controlled, and that the reaction of fuel and oxygen is infinitely fast. The mass fractions of all of the major reactants and products can be derived from the mixture fraction by means of "state relations," empirical expressions arrived at by a combination of simplified analysis and measurement. In this case the simulations were based on the reaction chemistry for "POLYURETHANE" as the majority of the products present will be cellulose and plastics based materials. The soot yield for the combustion chemistry was modified to ensure that a 10% soot yield was applied, this is consistent with the mix of cellulosic and plastic based materials likely to be present in the accommodation.

The model boundary conditions were assigned in the conventional FDS manner with all solid surfaces assigned thermal boundary conditions, plus information about the burning behaviour of the material. Usually, material properties are stored in a database and invoked by name. Heat and mass transfer to and from solid surfaces is usually handled with empirical correlations. Each material property is discussed below.

The modelling case was based on the architectural plan layouts for the central void space and fire affected apartment. In this case the model was built with a uniform mesh of dimensions 0.2m x 0.2m x 0.2m.

In order to ensure that sufficient ventilation was available for the fires to reach their peak fire sizes it was necessary to introduce inlet air into the compartments (by default the CFD models assume a perfectly sealed compartment which is not the case in reality). In order to ensure that the ventilation did not impact on the temperature and visibility profiles the inlet air was located at floor level as a 2.5sqm natural vent to outside. In addition each room window was modelled based on window breakage. The individual leakage vents were modelled using FDS's default "OPEN" vent criteria. This condition assumes a windless environment with the flow into or out of the domain being determined by the pressure difference between the inside and the outside of the modelling domain.

The only opening between the fire apartment and the balcony was taken to be the apartment entrance door for the sprinklered scenario. This is likely to be the case due to the suppression cooling the fire room and preventing the failure of the façade. In the code unsprinklered scenario window breakage is much more likely and therefore the extra openings on the balcony façade have also been opened in this unsuppressed scenario.

A steady state fire was applied to these models. The overall peak fire sizes was introduced into each scenario as a 1MW peak for the sprinklered actual scenario and 2.5MW in the prescriptive scenario. This was included in the models as a burner style vent releasing fuel at a rate equivalent to the medium growth rate. The overall heat release rate density was 250kW/m².

The above fire sizes have been taken from the smoke control association guidance on smoke ventilation in residential common corridors. It is noted that within this guidance there is reference to unsprinklered design fires reaching up to 6MW. In this comparison study a 2.5MW fire has been adopted on the basis that a larger fire would result in much greater failure of the non-fire rated sections of the apartment façade (and therefore much greater potential for smoke spillage onto the common areas). Additionally the larger fires would also produce greater quantities of combustion gases which would also contribute to further spillage onto the access balconies. Given that this study is intended to consider conditions on the external balconies for comparison purposes in this situation the unsprinklered, code compliant scenario is actually more conservative by using a smaller representative fire scenario. It is for this reason why the only opening from the apartment onto the balcony considered was the apartment entrance door and also why a 2.5MW fire was adopted.

For this scenario a steady state condition representing the worst case fire fighting period was used. In this case all parameters were steady state with the overall simulations run for 350s to ensure that conditions in the models had stabilised.

The ambient conditions within the model were taken as a temperature of 20°C and no wind.

Figures A1 and A2 illustrate the visibility profiles on the centreline of the balconies for the actual and prescriptive scenarios respectively after 350s. These two figures clearly show the better conditions present on the actual situation and therefore the acceptability of the proposed design.

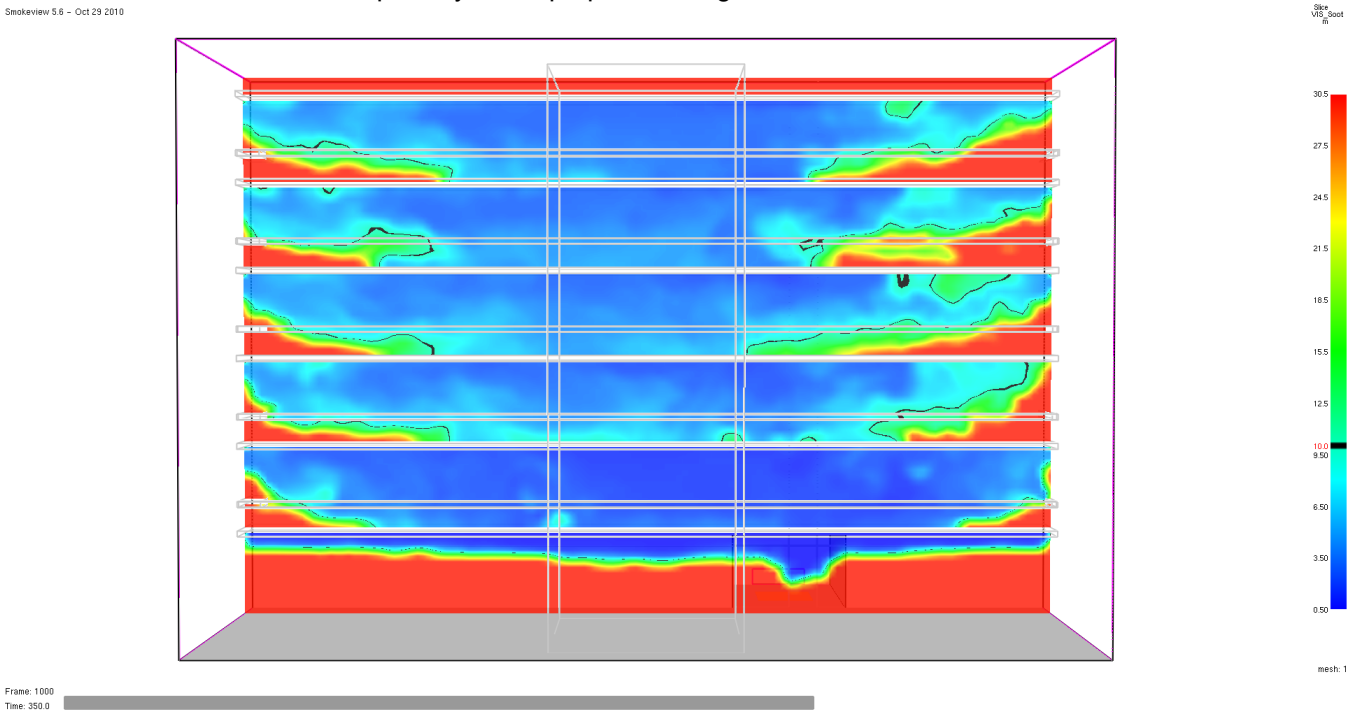


Figure A1 – Visibility prediction for the actual balustrade design after 350s

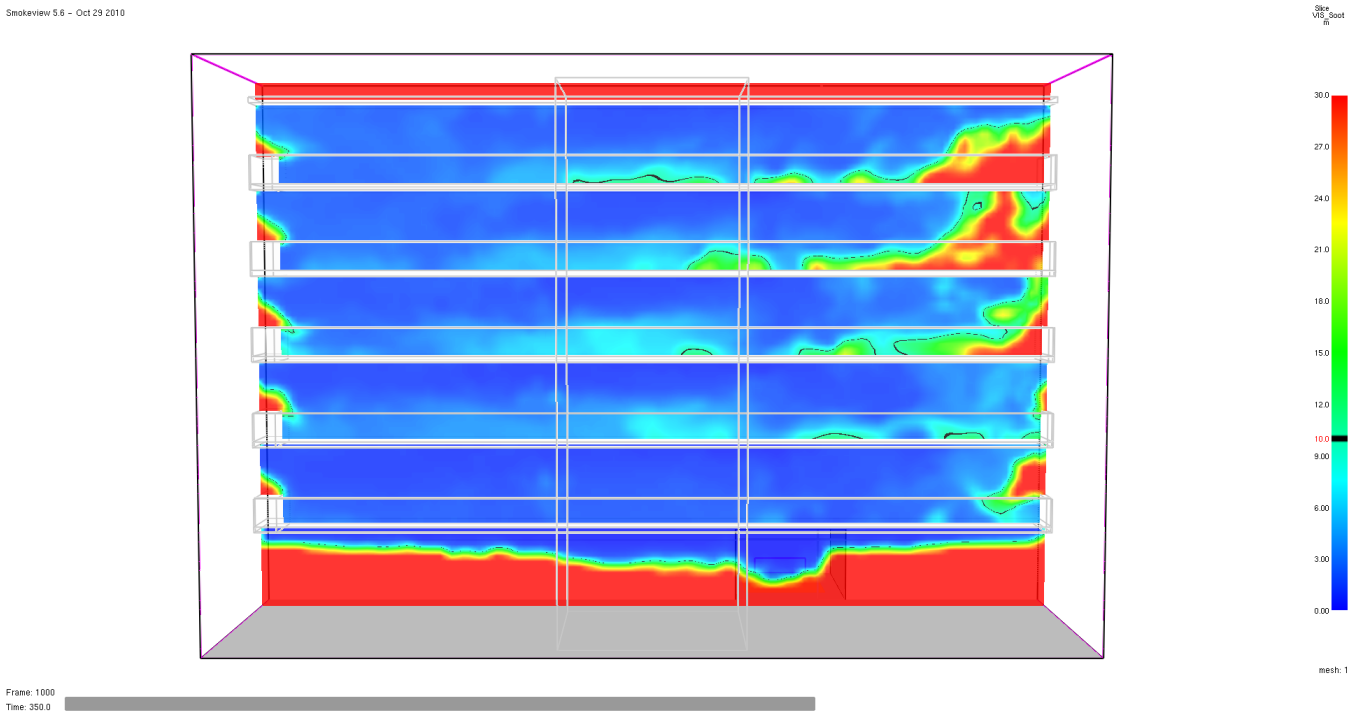


Figure A2 – Visibility prediction for the prescriptive balustrade design after 350s