AYLESBURY ESTATE

ROBUSTNESS CONSIDERATIONS

TO INFORM RISK ASSESSMENTS

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EXECUTIVE SUMMARY

We were appointed by the L.B. Southwark (LBS) to prepare calculations and a report to assist with the risk assessments necessary regarding the “robustness” of the large panel system residential blocks on the Aylesbury Estate, specifically a typical 4, 5 and 14 storey block. The study was also to consider the 6, 7 and 8 storey blocks. The brief was to assess the behavior of the blocks in the event of accidental loading in the two circumstances of piped gas being present or not and to consider the extent of strengthening which would be required for the blocks to comply with the BRE’s recommendations in their 1987 publication. The subsequent report was to summarize the structural engineering aspects of robustness and to inform the detailed risk assessments being prepared by others. The study has not considered the behavior of non-structural elements of the blocks in the event of accidental loading, such as windows and non load bearing wall panels.

We have already carried out investigations of the structure in flats in 5 storey and 14 storey blocks, studied archived information and spoken to one of the original contractor’s personnel present during construction in the late 60’s. We have not investigated a 4 or 6 storey block but consider that the structural arrangement will be sufficiently similar to a 5 storey for the purpose of this exercise. Similarly, based on the findings of the studies, we consider that the structure of the 7 and 8 storey blocks will be sufficiently similar to the 14 storey one investigated.

The calculations are based primarily on engineering judgement informed to an appropriate extent by standard design methods and post Ronan Point recommendations. Further site work and detailed design will be required to enable a strengthening scheme to be installed. This executive summary highlights the headlines from the study but should be read in conjunction with the main report to gain the full picture of what is a complex issue. Whilst the study has been taken far enough to satisfy the brief, it has, of necessity, not been exhaustive. The conclusions are based on the evidence gained during the work, together with our knowledge and experience of similar constructions. This report is for the sole use of the LBS.

In May 1968 a gas explosion caused partial collapse of a tower block called Ronan Point in Newham. The block was constructed of panels of prefabricated reinforced concrete, forming the walls, floors and roof slabs. There are many versions of this type of construction, commonly known as large panel systems (LPS). Ronan Point was constructed of the TWA system whilst the Aylesbury Estate is built of the Jespersen system. In the event of accidental loading, usually a gas explosion, the original design of most LPS blocks meant that one explosion could result in many dwellings suffering. This is known as “disproportionate” collapse, i.e. the damage is disproportionate to the cause.

Avoiding disproportionate collapse is a fundamental concept for designing and checking buildings. Regrettably explosions, usually gas, do occur and cause collapse of residential properties. Avoiding disproportionate collapse ensures that the structure of a building is designed or strengthened to ensure that damage is relatively limited. Local damage cannot be avoided and for LPS buildings in particular, flats adjacent to, above or below the location of the explosion may be substantially damaged. Some elements of the structure may be

blown out and cracking and deflection of floors are possible in other parts of the building, particularly above the explosion. These effects are not considered to be disproportionate.

We are unsure of the full extent of piped gas supply to dwellings on the Estate, but our report considers both scenarios of gas present or not. Whilst a gas leak is likely to originate in the kitchen, an explosion can occur in any room but with perhaps the larger rooms most likely to contain sufficient gas to cause significant damage. If piped gas is removed from a dwelling, the risk of an explosion is substantially reduced and as a consequence, the accidental loading to be designed for is halved. The most likely cause of an explosion other than piped gas is bottled gas. It is understood that acetylene gas bottles are present in some of the garages in the 5 storey blocks at the Aylesbury Estate.

It is impossible to accurately model the behavior of a building under explosive loading but recognized techniques, combined with engineering judgement and reference to the behavior of Ronan Point enable a reasonable assessment to be made. We do not consider it feasible to retain the gas supplies and strengthen to the required standard. However removal of a gas supply increases the load on the electrical system and encourages the use of bottled gas. The uncertainty of the real load associated with an explosion from bottled gas suggests it should not be allowed in any block and Housing Management should be vigilant to this.

We consider the extent of strengthening suggested in the report, and the proposed alterations and new build work to the South West corner buildings, of whatever height, would comply with the December 2004 Building Regulations. However this issue is complex and requires written confirmation of LBS Building Control's position.

This report is intended to inform the risk assessments necessary to consider the robustness of the large panel system blocks on the Aylesbury Estate. Whilst these assessments will enable LBS to decide its future strategy, we consider that the 7, 8 and 14 storey blocks do comply with reasonable robustness criteria although local damage would occur in the event of accidental load. If present, piped gas need not be removed, nor is any form of strengthening work required. Similarly whilst progressive collapse is possible in a 4 storey block in the event of accidental loading, the extent of damage would not be considered as disproportionate and again therefore, no action need be taken. Our work on the 5 and 6 storey confirms that they have not been designed or constructed to avoid disproportionate collapse. This is contrary to what we consider a reasonable criteria i.e. the BRE's 1987 recommendations.

The top floor of any block need not be strengthened since collapse of the roof in the event of an explosion at top storey would not constitute disproportionate collapse, assuming the floor beneath is able to take the debris loading.

Whilst we would not support a policy of merely removing the gas supplies and not strengthening, we accept that gas removal alone significantly reduces the risk of an explosion. We therefore recommend that it should be carried out as a matter of high priority, to be then followed by phased and well considered strengthening programme. We would also recommend that the HSE is notified of the current situation.

Strengthening work would essentially involve the fixing of steel plates to floors, top and bottom sometimes, and steel angles at wall/floor joints. This would not be required throughout the whole block and the main report broadly identifies which dwellings would be affected and to what extent.

1. INTRODUCTION

1.1. Brief

1.1.1. Alan Conisbee and Associates, consulting structural engineers, were appointed by Mr N Kirby of London Borough of Southwark on the 21st January 2005 to prepare calculations and a report to assist with the risk assessments necessary regarding the "robustness" of the large panel system residential blocks on the Aylesbury Estate.

1.1.2. After detailed discussion with the client and Calford Seaden, chartered surveyors and health and safety consultants, on the extent of the scope of this study, we were asked to consider a typical 4 storey block, a typical 5 storey one and a typical 14 storey one. We were also asked to briefly consider the situation with the 7 and 8 storey blocks. Our brief was to consider the behavior of the blocks in the event of accidental loading (usually an explosion) in the two circumstances of piped gas being present or not. We were also to consider in broad terms, the extent of strengthening which would be required for the blocks to comply with the BRE's recommendations in their 1987 publication "The structural adequacy and durability of large panel system dwellings". We were then to assess the behavior of the strengthened blocks under the same two circumstances.

1.1.3. Our study was to be presented in a report which would summarize and clarifying as necessary, the structural engineering aspects of robustness, to inform Calford Seaden's risk assessment.

1.1.4. Our brief did not include such issues as the likelihood of accidental loading occurring nor were we required to comment on other health and safety issues, such as the presence of asbestos, risks involved of carrying out work to the blocks with residents in occupation and so on. Where appropriate however, brief general comments on such issues are made below.

1.1.5. Our study has not considered the behavior of non-structural elements of the blocks in the event of accidental loading, such as windows and non load bearing wall panels, which if displaced would have implications for health and safety.

1.2. Investigative Procedures

1.2.1. We have already carried out detailed investigations of the structural arrangement in flats in 5 storey and 14 storey blocks, studied archived information and spoken to Bill Patrickson, one of the original contractor's personnel present on site during construction. We have not investigated a 4 storey block but consider that its structural arrangement will be sufficiently similar to a 5 storey for the purpose of this exercise. This view is based on our experience of LPS buildings in general and is expanded upon in Section 5.1.1. below.

1.2.2. An interim report was presented on 15th November 2004 giving initial findings and recommendations. For full details of that work, reference should be made to that report. For completeness however, and to enable this current report to "stand alone", the essence of this previous work has been included here.

1.2.3. Our current work has involved the preparation of calculations which are based primarily on engineering judgement informed to an appropriate extent by standard design methods and post Ronan Point recommendations. The Aylesbury Estate was designed before the advent of "limit state" design, and whilst this method can have advantages for new build construction, it can, subject to certain criteria, be considered acceptable to assess an existing building using the basis of design of the British Standard Code of Practice in use at the time of construction. These criteria include reasonable service life behaviour, i.e. assuming no significant structural problems during the life of the building, and assuming subsequent codes of practice have not highlighted genuine deficiencies in the previous one.

1.2.4. To the extent to which the old code is used in this report, these criteria have been broadly satisfied here at the Aylesbury Estate. Reference has therefore been made to CP114, "Reinforced Concrete in Buildings", and the "load factor" method in particular. The load factor method remains a valid method of analysing reinforced concrete. The allowable stresses for the structural materials involved have been increased in accordance with generally accepted wisdom when checking for resistance against accidental loading.

1.2.5. Further site work and detailed design will be required to enable a full remedial scheme to be developed, costed and installed but that is not part of this current commission.

1.3. This Report

1.3.1. Following this introductory section, Section 2 of this report gives some background on the issue of robustness in large panel system buildings, and the Aylesbury Estate in particular. The three types of blocks, 4, 5 and 14 storey respectively, are then considered in detail in the subsequent Sections, 3, 4 and 5. Each of these three Sections includes our detailed findings and conclusions, as required by the brief. For ease of reading however, a Section 6 is included which summarizes those conclusions from the previous Sections.

1.3.2. Appendices are used for the calculations which may be of interest to some readers. The important findings and conclusions from the calculations are included however in the main text of the report.

1.3.3. This report details the findings and conclusions of Alan Conisbee & Associates' work in response to the brief. Whilst it has been taken far enough to satisfy the requirements of that brief, it has, of necessity, not been exhaustive. The findings cannot therefore be warranted to apply to areas of the buildings not inspected or investigated. The conclusions and recommendations are based on the available evidence gained during the inspections and research, together with Alan Conisbee & Associates’ knowledge and experience of similar constructions. This report is for the sole use of the London Borough of Southwark and Calford Seaden in connection with the Aylesbury Estate and no responsibility is accepted to any other party.

2. RELEVANT RISK ISSUES

2.1. History

2.1.1. In May 1968 a gas explosion caused partial collapse of a tower block called Ronan Point in Newham. The block was constructed of panels of prefabricated reinforced concrete, forming the walls, floors and roof slabs. There are many versions of this technique of construction, commonly known as large panel systems (LPS). Ronan Point was constructed of the TWA system whilst the Aylesbury Estate is built of the Jespersen system.

2.1.2. In the event of accidental loading, usually a gas explosion, the original design of most LPS blocks meant that one explosion could result in many dwellings suffering. This is known as “disproportionate” collapse, i.e. the damage is disproportionate to the cause. At the 22 storey Ronan Point, the explosion occurred on the 18th floor, blowing out supporting walls. This caused the floors and walls above to fall. Their weight overloaded the floor below and a domino effect occurred down one corner of the whole block. This type of collapse is sometimes therefore referred to as “progressive” collapse.

2.2. Disproportionate Collapse

2.2.1. Avoiding disproportionate collapse is a fundamental concept for the design of new buildings and for checking existing ones. It has to be accepted that regrettably explosions, usually gas, do occur and can cause collapse of residential properties. Avoiding disproportionate collapse ensures that the structure of a building is designed or strengthened to ensure that damage is relatively limited.

2.2.2. It should be recognised however that local damage cannot be avoided and for LPS buildings in particular, flats adjacent to, above or below the location of the explosion may be substantially damaged. Some elements of the structure, such as wall panels, may be blown out by the explosion. Significant cracking and deflection of floors are possible in other parts of the building, particularly above the explosion. All of these effects are not considered to be disproportionate. This philosophy is considered in more detail in Section 3.2 below.

2.3. Accidental Loading

2.3.1. Accidental loading, sometimes referred to as “abnormal” loading is a term meaning any load not normally expected during the life of the structure, such as a gas explosion or vehicle impact. We are currently unsure of the full extent of the gas supply to dwellings on the Estate. This report considers both cases of gas present or not.

2.3.2. The gas leak which resulted in the Ronan Point incident resulted from a faulty connection to the cooker. In 1968 "town" gas was used, rather than the "North Sea" gas used today. There may be differences in these two, for example it is understood that town gas is lighter than air and hence rises whilst the gas used nowadays is heavier than air and therefore begins to collects at floor level. Such a difference may have a theoretical effect on the likelihood of an explosion and its location, particularly in the maisonette dwellings where gas can move from one storey to another. In terms of the effect of an explosion on the structure however, the two types of gas are treated as the same.

2.3.3. At Ronan Point, the gas spread from the kitchen into other rooms and as a result several explosions occurred very quickly, one after the other as the gas in one room was ignited by the explosion in the adjoining room. This is known as a cascade effect. The explosion which caused the load bearing wall to blow out occurred in the lounge. The relevance of this to the current study is that whilst a gas leak is likely to originate in the kitchen, an explosion can occur in any room but with perhaps the larger rooms most likely to contain sufficient gas to cause significant damage.

2.3.4. If piped gas is removed from a dwelling, the risk of an explosion is substantially reduced and as a consequence, the load to be designed for is halved to 17kN/sq.m. It should be appreciated that this is still a relatively large load, for example it is more than 10 times the load for which a domestic floor is designed. The most likely cause of an explosion other than piped gas is bottled gas, for example as sometimes used for heating. There is anecdotal evidence that acetylene gas bottles are present in some of the garages in the 5 storey blocks at Aylesbury Estate.

2.3.5. Another example of accidental loading which could cause damage to a building is vehicle impact. This would occur at ground level and the significant weight of the building above helps in keeping the building stable. It is impossible to realistically model the effect of vehicle impact, since the load on the building from it depends on how much and how quickly the vehicle deforms, as well as the more obvious factors such as its weight and speed. A standard car is unlikely to displace a load bearing wall but a heavy lorry may.

2.4. Regulations

2.4.1. The history of the regulations that followed the partial collapse at Ronan Point is complex and has sometimes caused misunderstanding. The Ronan Point enquiry produced recommendations (MHLG Circular 62/68) requiring all LPS blocks to be tied together to avoid disproportionate collapse. This initially referred to buildings where piped gas was provided, and hence the risk of an explosion significantly higher, and required the structure to withstand a force, referred to as an equivalent static pressure (e.s.p.) of 5 p.s.i. (34kN/sq.m). Another MHLG circular soon followed however (71/68) which required a similar approach to be taken for buildings to which gas was not supplied but the e.s.p. which the structure must withstand was reduced to 2.5 p.s.i. (17kN/sq.m).

2.4.2. For a short period, these requirements only applied to buildings over 6 storeys but in 1970, the revised Building Regulations clarified that the requirement applied to buildings above 4 storeys. The Building Regulations were and are not retrospective however so any 5 or 6 storey blocks which were completed by 1970 would not have been picked up as requiring strengthening. It may be argued that it was not until 1987, when the BRE recommendations required all existing LPS blocks to be checked for robustness if greater than 4 storeys, that the situation was clarified.

2.4.3. Most LPS buildings being designed and/or built after Ronan Point were greater than 6 storeys and were therefore strengthened to comply. However a number of 5 and 6 storey blocks were left un-strengthened and some of them were not then picked up following the BRE's recommendations. This has occurred on other estates in London and also appears to explain the current situation at the Aylesbury Estate.

2.4.4. Reference to dates on archive material and a conversation with Bill Patrickson confirm that the Estate was being designed and constructed around the time of the Ronan Point incident but was probably effectively complete by 1970 when the revised Building Regulations were issued. This timing explains why the 5 (and probably the 6 storey) blocks on the Estate did not comply whereas the 14 storey ones did.

2.4.5. The Building Regulations have always referred to contemporary codes of practice as one way of achieving a satisfactory design and for several years now these codes have not differentiated between buildings which are provided with gas and those which are not. Thus, strengthening in accordance with them has required a design to take the 34kN/sq.m accidental loading. However design in accordance with a code of practice is not considered the only way to produce a satisfactory design and the use of engineering judgement is therefore permitted and indeed essential when considering existing buildings. The Building Regulations are not retrospective but inevitably their current requirement is a factor which can influence the appraisal of an existing structure.

2.5. The Current Building Regulations

2.5.1. The Building Regulations (Part A - Structure) are regularly revised and the latest revision was issued on 1st December 2004. It now includes for some of the requirements for robustness, specifically the horizontal tying requirement, to apply to all residential blocks of flats regardless of height. If the four storey blocks were to be constructed today, they would therefore require the horizontal tying to be included, as for a 5 storey (or more) block, although the vertical tying requirement remains applicable only to 5 storey (or more). This emphasizes the need when assessing existing buildings with regard to Building Regulations, for judgement, research and experience to be applied. Regulation 8 of the current Regulations places a limit on all requirements such that they “shall not require anything to be done except for the purpose of securing reasonable standards of health and safety for persons in or about buildings.”

2.5.2. The NHBC has produced a useful Technical Guidance Note “The Buildings Regulations 2004 Edition Requirement A3 – Disproportionate Collapse”. This includes a section on “conversions”, i.e. working with existing buildings, which is relevant. It suggests that if a “change of use” does not take place the regulations do not apply. This is the case with both this current appraisal of the Estate and the refurbishment work proposed for the South West corner.

2.5.3. The Guide also helps with regard to work on existing buildings, so is relevant to the South West corner. Building work which requires A3 to be considered includes extension of that building or material alteration to it. “Material” means (i) an alteration which results in a building not complying with A3 where previously it did or (ii) an alteration which results in a building which previously did not comply now being more unsatisfactory in relation to A3.

2.5.4. Regulation 4 seems to say that in essence, an alteration or extension to a building which did not previously comply with A3, is permitted providing that work does not make the building less satisfactory with regard to A3 than before, i.e. the original building does not need to be strengthened to comply although the new extension would need to.

2.5.5. We consider the proposed alterations and new build work to the South West corner buildings, whatever height, to be in this category. We believe that the new infill buildings are not “extensions” of existing buildings but would be designed as stand alone structures, albeit directly adjacent to the existing flank wall. Clearly the proposed strengthening for the 5 storey blocks will make the situation significantly better, although not fully compliant with current codes and therefore A3 need not apply. Similarly, the work on the 4 (and 14) storey blocks will not worsen the situation so again, A3 does not have to be met.

2.5.6. Discussions in autumn last year with the Borough’s Head of Building Control confirmed that providing any proposed work on the existing blocks would not make the situation worse, he would not require the current Regulations to be followed. However this issue is complex and requires written confirmation of Building Control’s position.

2.6. Technical Aspects

2.6.1. It is impossible to accurately model the behavior of a building under explosive loading but recognized techniques, combined with engineering judgement and reference to the behavior of Ronan Point enable a reasonable assessment to be made. There are two fundamental problems encountered when checking buildings for resistance to accidental loading.

2.6.2. The behavior of the building depends on many factors, such as the strength of materials used, design of joints, accuracy of construction, workmanship and so on. Whilst reasonable estimates can be made, and are reasonably reliable when considering normal loading, the extreme loads which occur with accidental loading require somewhat unusual assumptions to be made. The BRE are currently undertaking testing work on existing but redundant tower blocks with a view to giving more accurate information for this. The results of their work may be available formally in one year or so but is apparently indicating that, as expected, the structures under test are more robust than theory predicts.

2.6.3. The second problem is quantifying accidental loads. For example, whilst much study has been made of the Ronan Point incident, the loading which actually occurred can only be approximated to between 3 and 12 p.s.i. (20 and 80kN/sq.m). This large spread illustrates that there is, inevitably, substantial uncertainty when dealing with gas explosion effects. In this light, the requirements of 2.5 and 5 p.s.i. can be seen as no more than reasonable estimates. In the event of an explosion, venting would occur whereby some of the pressure would be reduced by the blowing out of windows, doors and non load bearing walls. There is no way of quantifying this however and it is effectively included in the designed e.s.p. requirements of 34 or 17 kN/sq.m. Large amounts of venting occurred at Ronan Point but the pressure was still sufficient to displace a load bearing external wall.

2.7. Gas Removal and Strengthening Work

2.7.1. In our opinion and experience it is not feasible to retain the gas supplies and strengthen to the more onerous requirement of 5psi (34kN/sqm). The extent of such work, the disruption and the costs involved are considered sufficient to exclude this as a realistic option. The strengthening work incorporated in the 14 storey blocks on the Estate was designed in before construction. We know of no LPS block where post construction strengthening has been carried out to the 34kN/sq.m requirement.

2.7.2. Removal of a gas supply increases the load on the electrical system. This requires checking by an electrical engineer. It also encourages the use of bottled gas. The uncertainty of the real load associated with an explosion from a bottled gas container suggests that bottled gas should not be allowed in any building. Housing management should be vigilant to this.

2.7.3. Strengthening work would essentially involve the fixing of steel plates to floors, top and bottom sometimes, and steel angles at wall/floor joints. This would not be required throughout the whole block and Sections 4 and 5 below identify broadly which dwellings would be affected and to what extent.

2.7.4. The top floor of any block need not be strengthened since collapse of the roof in the event of an explosion at top storey would not constitute disproportionate collapse, assuming the floor beneath is able to take the debris loading. This is considered in more detail in Section 4.2.3. below.

2.7.5. The presence of Artex ceilings and floating timber floors (both of which are believed to contain asbestos) necessitates careful removal work by a qualified specialist before the strengthening work can be undertaken. It is understood that some asbestos removal has been carried out on the Estate but apparently this has not included the material under the floor. The strengthening work requires a positive connection to be made to the concrete slab, so disturbing the void beneath the floating floor is inevitable.

2.7.6. Experience suggests that the noise and disruption involved in strengthening work, particularly drilling in to the concrete elements not only affects the dwelling being worked on but is sufficient to effect the whole block by structure-borne vibration creating noise remote from the source. It is difficult to assess the effect of this on residents, clearly being very dependant on the resident’s personal tolerance. Temporary refuges, effectively purpose fitted out “site huts”, can be used as an alternative to decanting.

3. FOURTEEN STOREY BLOCK

3.1. Investigations

3.1.1. Flat 152 Bradenham has been investigated including opening out works to expose as built details. It is a mid terrace one bedroom flat located on the 9th floor and accessed from the 8th floor access corridor. From archives, it has been possible to assess and compare the “as designed” and “as built” construction and to consider the design intent.

3.1.2. Large vertical continuity bars grouted into wall panels were found together with restraint hoops within floor panels and lacer bars within the in situ stitch floor/wall joints, such details corresponding with archive details. In addition the staircase/wind walls were found to be tied to the party walls with horizontal hoop bars and vertical lacer bars. All exposed in situ concrete within stitch joints and mortar within dry pack joints was found to be dense and well compacted.

3.1.3. The purpose of the investigations in this flat was to establish whether the design intentions regarding disproportionate collapse, as shown on the original drawings, had been followed during construction. Other details which may be relevant to the extent of local damage as required for this risk assessment study but which are not directly relevant to disproportionate collapse, have not been fully established, either from site survey work or archive study. Reasonable assumptions have been made therefore predict behaviour as detailed below. Further investigations are not considered necessary.

3.2. Conclusions

3.2.1. It is clear that the block was designed and constructed in accordance with the post Ronan Point requirements, assuming piped gas is present, i.e. to take an e.s.p. of 5 p.s.i. (34kN/sq.m). Whilst these conclusions are based on the opening up in one flat only, the archive information and Bill Patrickson’s evidence suggests that it is reasonable to assume that the remaining high rise blocks on the estate (i.e. 7 storey and over) have been designed in accordance with these requirements. For an estate of this size and the level of organisation which must have been used to ensure completion it seems most unlikely that the extra work required to design the 14 storey Bradenham block would not have been applied to all 14 storey blocks. If further confirmation is required however, a limited survey can be carried out.

3.2.2. Their robustness is achieved by the inclusion of particularly strong floor and wall units in critical locations along with significant amounts of tying reinforcement, including with “wind walls”. Details are included in the appendices. This approach is economical and justified but it does mean that in the event of an explosion, some of the “non-critical” wall and floor units are likely to break and/or be blown out. The building would remain standing and disproportionate collapse would not occur but the storeys directly above and below the explosion are likely to receive significant damage. The flat(s) on the other side of the party wall(s) could also be affected.

3.2.3. Whilst the archive information has been comprehensive enough to reach the definite conclusion above, it is not complete and therefore the following assessment of the extent of non-critical elements must be considered as a reasonable assessment rather than a definitive summary. It is also impossible to quantify the effects of interaction between the critical and non critical structural components.

3.2.4. For example, joints between wall and floor panels are profiled (‘castellated’) and filled with in situ concrete and it is therefore likely that the weaker non critical units will not act completely independently of adjoining stronger critical units. The presence of ‘Siporex’ partition walls may also influence the failure mode of floors and possibly walls. The spandrel panels under the windows are believed to be bolted to the ends of the party walls so again, they may help in restraining load bearing walls but it is not possible to quantify that effect. These effects are sometimes referred to as “secondary effects”.

3.2.5. On this basis, and being aware of the all the other uncertainties, the following is considered a reasonable estimation of possible effects. In an end flat, approximately one quarter of floor units, end wall units and party wall units are likely to behave as “non critical”. In a flat adjacent to a stair core, approximately one half of floor units, one third of stair core wall and party wall units are likely to behave as non critical. In a flat sandwiched between other flats, approximately one half of the floor units and one third of the party wall units are likely to behave as non critical.

3.3. Piped Gas Explosion - Floors

3.3.1. The critical floor units would withstand the explosion, thus maintaining the structure of the building.

3.3.2. The non critical floor units of the room in which the explosion occurred would fail, with much of the concrete, either as a complete unit, or more likely as large fragments dropping on to the floor beneath. The reinforcement may stay in place, hanging “in catenary” possibly holding some of the concrete.

3.3.3. The non critical floor units above the location of the explosion would also fail in a similar fashion, causing damage to the storey above the explosion. Debris would fall back to the location of the explosion and possibly through to the floor below.

3.3.4. That floor would take the debris loading of those two failed floors although minor cracking may occur. The storey beneath that would be unlikely to be affected by the explosion other than from noise, broken glass and the like.

3.4. Piped Gas Explosion - Walls

3.4.1. The critical wall units would withstand the explosion, thus maintaining the structure of the building.

3.4.2. The non-critical internal walls would fracture, possibly causing damage by fragments of concrete being blown into the space on the other side of the wall. This would occur to the walls directly either side of the location of the explosion, at whatever storey that occurs in the block. If the blocks were taller, only the top ten storeys would suffer this effect.

3.4.3. For the top three storeys of the block, the joint at the top of the wall would fail, possibly resulting in the wall being blown out as a unit in to the space next door. For the top four storeys, the joint at the base of the wall may also fail, with similar consequences.

3.4.4. The weight of fallen wall units would not overload the floor units unaffected by the explosion.

3.4.5. The non-critical external (end) walls would fracture, possibly causing damage by fragments of concrete being blown out.

3.4.6. The joint at the top of an external wall panel would not fail but for the top five storeys, the joint at the base of the wall may, causing the whole panel to be blown out.

3.5. Other Explosion - Floors

3.5.1. If gas is present, it does not need to be removed from the 14 storey blocks in our opinion and based on our investigation work, but for completeness the following considers the structural behavior if assessed for the 17kN/sq.m “e.s.p”. rather than the 34kN/sq.m required for piped gas.

3.5.2. There is insufficient evidence to assess whether the non critical floor units of the room in which the explosion occurred would fail. If they did it is possible that significant cracking only may occur, with the unit staying in place, rather than the extent of damage detailed above in Section 3.3.2.

3.5.3. The non critical floor units above the location of the explosion are likely to fail in a similar fashion as described in Section 3.3.3. however. Debris would fall back to the location of the explosion and the floor would probably take that load. At worst the floor may then fail but as in Section 3.3.4 the floor below that would take the debris load.

3.6. Other Explosion - Walls

3.6.1. The non-critical internal walls units would not fracture nor would there be a problem with the joint at the top of each panel. However for the top 2 storeys of the block, the joint at the bottom of the wall would fail, possibly resulting in the wall being blown out as a unit in to the space next door.

3.6.2. The non-critical external (end) walls would not fracture, nor would there be a problem with the joint at the top of each panel. However for the top storey alone, the joint at the bottom of the wall would fail, possibly resulting in the wall being blown out as a unit.

3.7. Summary

3.7.1. Consideration of the 14 storey blocks in this report is an attempt to provide a benchmark for a comparison with the 4 and 5 storey blocks as detailed in the Sections below. Based on the evidence, we consider there is no need for any action to be taken with regard to the 14 storey blocks on the Estate. If gas is present, it need not be removed nor is any strengthening required. The above section has illustrated however the extent of local damage possible in the event of accidental loading in a structure which nevertheless satisfies reasonable robustness criteria.

4. FIVE STOREY BLOCK

4.1. Investigations

4.1.1. We have carried out exploratory investigations in a total of 6No flats within the 5 storey blocks in the SW corner of the Estate. The form of construction within these units was found to be broadly similar to that within the 14 storey block, i.e. large concrete panels forming the walls and floor but differing significantly in jointing details. Notably only very few small diameter mild steel bars were found within the party wall construction and no evidence of restraint hoops were detected within floor slabs albeit small size high tensile bars were noted within the joints between floor units. Also the staircase/wind walls do not appear to be tied to the party or end walls. It is also structurally significant that in the end bay no evidence of slab units or in situ strips designed to withstand uplift forces have been detected. However all exposed in situ concrete within stitch joints and mortar within dry pack joints was found to be dense and well compacted.

4.1.2. Archive records for the 5 storey blocks contain architectural layouts and details but not engineering details, as were found for the 14 storey blocks. Reference was made to previous Jespersen general details contained in our in-house records.

4.1.3. The purpose of the investigations in these flats was to establish whether or not the design and construction had considered disproportionate collapse. As with the 14 storey blocks, other details which may be relevant to possible local damage but which are not directly relevant to disproportionate collapse, have not been fully established, either from site survey work or archive study. Reasonable assumptions have been made therefore predict behaviour as detailed below. Further investigations are not considered necessary until, and if strengthening work is to be progressed, see Section 4.7. below.

4.2. Conclusions

4.2.1. The 5 storey blocks have not been designed or constructed to avoid disproportionate collapse in the event of accidental loading. Whilst these conclusions are based on the opening up in only two blocks on the Estate, Bill Patrickson's evidence suggests that it is reasonable to assume that the remaining 5 and 6 storey blocks on the estate will all be the same in this regard. If strengthening of these blocks is progressed however it would be prudent to do a limited check on each block, in the unlikely event that it had been designed for disproportionate collapse.

4.2.2. Unlike the 14 storey blocks, these blocks do not include strong floor and wall units in critical locations and tying reinforcement. In principle therefore, if a load bearing internal or external wall was to be removed by accidental loading, the floor above that would fall, along with the wall above, and then the floor that it supports in turn. The weight of the falling wall and floor units is likely to overload the floor beneath which in turn would probably collapse, resulting in a typical progressive collapse which would be considered disproportionate.

4.2.3. In the event of accidental loading displacing a load bearing wall in the top storey however the weight of the roof slab and displaced wall would be most unlikely to overload the floor beneath so whilst significant damage would occur, the collapse would be localised and not considered disproportionate. On this basis, the top floor need not be strengthened although in some flats, see Section 4.3. below, the floor slab would need to be strengthened to deal with accidental loading from the storey beneath. The client may consider therefore that the extra cost associated with strengthening the top floor walls and roof, is worth spending to increase resident confidence in the building.

4.2.4. Whatever approach to this issue is taken, it would still be necessary to remove piped gas from the top storey as well as the rest of the block to avoid the risk of gas seeping into a storey below.

4.2.5. Some of the secondary effects mentioned in Section 3.2.4. above will apply to the 5 storey blocks and have some influence on the behavior of the structure under accidental loading but none are considered likely to be significant enough to prevent disproportionate collapse.

4.2.6. On this basis, and being aware of the all the other uncertainties, the following is considered a reasonable estimation of possible effects.

4.3. Piped Gas Explosion - Floors

4.3.1. The floor units of the room in which the explosion occurred would fail, with much of the concrete, either as a complete unit, or more likely as large fragments dropping on to the floor beneath. The reinforcement would be unlikely to stay in place since there is no tying reinforcement from the slab to the floor/wall joint, as there is in the 14 storey blocks.

4.3.2. The floor units above the location of the explosion would also fail in a similar fashion, causing damage to the storey above the explosion. Debris would fall back to the location of the explosion and possibly through to the floor below.

4.3.3. If the accidental loading occurred in the top storey, it may be that the floor of the storey below would take the debris loading of the failed 4th floor and roof and possible displaced walls, thus avoiding disproportionate collapse although this could not be relied on.

4.4. Piped Gas Explosion - Walls

4.4.1. The internal walls could fracture, possibly causing damage by fragments of concrete being blown into the space on the other side of the wall. This would occur to the walls directly either side of the location of the explosion, at whatever storey that occurs in the block.

4.4.2. Since these walls are the only vertical load bearing elements of the structure, it may be that they are sufficiently damaged to no longer take that load, thus allowing the walls and floors above to fall.

4.4.3. For all but the ground floor storey, the joint at the top of the internal wall could fail, possibly resulting in the wall being blown out as a unit in to the space next door, with subsequent collapse of floors and walls above. Similarly for the top four storeys, the joint at the base of the internal wall may also fail, with similar consequences.

4.4.4. The external (end) walls would fracture, possibly causing damage by fragments of concrete being blown out. As for the internal load bearing walls, it may be that they would be sufficiently damaged to no longer take load, with collapse above occurring.

4.4.5. The joints at the top and bottom of an external wall panel could fail at any height of the 5 storey block, causing the whole panel to be blown out and the structure above to fall.

4.4.6. The removal of floor units in the event of a piped gas explosion would have significant implications for the walls. Even if a wall remains in place despite the accidental loading, the absence of a floor to provide some amount of lateral restraint would cause it to become unstable under normal loading such as wind and eccentric loading. For internal walls there will be an intact floor on at least one side of the wall but for an external wall, it is most unlikely to remain stable if required to span the 5m or so between two floor levels, particularly with the weakness at “mid-height” joint where the missing floor used to be and the eccentric load of the external skin.

4.5. Other Explosion – Floors

4.5.1. If the piped gas is removed from the 5 storey blocks the reduced e.s.p. of 17kN/sq.m greatly reduces the potential damage although the floor units of the room in which the explosion occurred would probably fail, particularly in the absence of the tying reinforcement, as described in Section 4.3.1. above.

4.5.3. The floor units are particularly weak when taking load from beneath so again, floor units above the location of the explosion would also fail.

4.5.4. The comment in Section 4.3.3. applies.

4.6. Other Explosion - Walls

4.6.1. Under a load of 17kN/sq.m the internal wall slab themselves are most unlikely to fracture and their top joint connection would also remain intact. However, for the top two storeys, the joint of the wall at the base may fail possibly resulting in the internal wall being blown out as a unit in to the space next door, with subsequent collapse of floors and walls above.

4.6.2. As for the internal walls, the external (end) wall slabs themselves would not fracture but the connection at the top of the wall may fail at any floor level other than the ground floor storey. The panel may be displaced and collapse may then occur. Similarly the joint at the bottom of the external wall at the top floor is likely to fail, although as discussed above the subsequent failure of that wall and the roof slab is not considered to be disproportionate.

4.6.3. As detailed in Section 4.4.6. above, the likely removal of floor units, even under an accidental load of 17kN/sq.m has significant implications for the walls and strengthening would need to address this.

4.7. Summary

4.7.1. The 5 storey blocks have not been designed or constructed to avoid disproportionate collapse in the event of accidental loading and our recommendation remains that the gas should be removed from these blocks (and 6 storey blocks) with some strengthening detailed below. We believe that the BRE's 1987 recommendations effectively summarised the rigorous and well considered thinking which developed in the two years or so which followed the Ronan Point incident and as such we consider them reasonable and appropriate for appraisal of existing LPS buildings today.

4.7.2. The joint of an internal wall at its base to the floor should be strengthened at the 4th storey using a steel cleat bolted into the concrete of the floor and wall units. For the external (end) walls similar strengthening would be necessary at the top of the wall at its junction with the ceiling for all storeys other than the ground floor.

4.7.3. The most intrusive strengthening work involves the application of steel plates to help floor slabs stay in place and thus aid overall stability in the end flats. At all four levels above ground, the floor slab would need these plates applied on both top and the soffit in the end flats only. Subject to precise details in dwellings adjoining stair cores, it may be that steel plate strengthening is needed in those dwellings also.

5. FOUR STOREY BLOCK

5.1. Investigations

5.1.1. We have not carried out exploratory investigations in any flats in the 4 storey blocks on the Estate but believe the form of construction within these units will be as found in the 5 storey blocks. We reach this conclusion because of our understanding of the philosophy behind using an LPS to build. The key to economic building was, and arguably still is, repetition. The more identical pre-cast units that are produced they cheaper they become. Whilst it is possible that the 4 storey blocks are of a different form of construction to the 5 storey block, our experience with LPS blocks suggests this is most unlikely. We are unable to comment on the level of workmanship but have no reason to believe it to be any worse than for the other Jespersen blocks on the Estate.

5.1.2. We have not looked for archive records for the 4 storey blocks but assume that, as for the 5 storey blocks, architectural but not engineering information will be available.

5.1.3. The purpose of including the 4 storey blocks in this commission is for completeness and to enable the client to gain as full a picture as possible on this complex issue. To assess the behaviour of these blocks under accidental loading, reasonable assumptions have been made. Further investigations are not considered necessary unless the client wishes, contrary to our recommendation, to progress strengthening work, in which case sample exploratory opening up should be carried out in limited areas to confirm our assumptions.

5.2. Conclusions

5.2.1. In our opinion and understanding of current requirements, there is no requirement for the 4 storey blocks on the estate to comply with robustness considerations. If accidental loading occurred and caused progressive collapse as described in Section 4.2.2., this would not be considered as disproportionate to the cause. Piped gas can therefore remain and strengthening is not required.

5.2.2. The background to this may be difficult to understand but we understand that when the blocks were constructed, the safety of residents was considered in comparison to the many millions of people living in more traditional housing, such as brick houses, flats, tenement blocks and so on. As discussed in Section 2.4. above, the view was taken, after around one year of consideration, that only LPS blocks above 4 storeys represented an increased danger to the residents.

5.2.3. In the event of accidental loading occurring, the results would be broadly similar to that described above for the 5 storey blocks. For completeness, the text from above is included, somewhat edited and modified to apply specifically to the 4 storey blocks. The same caveats apply regarding lack of as built details and so on.

5.3. Piped Gas Explosion - Floors

5.3.1. The floor units of the room in which the explosion occurred would fail, with much of the concrete, either as a complete unit, or more likely as large fragments dropping on to the floor beneath.

5.3.2. The floor units above the location of the explosion would also fail in a similar fashion.

5.4. Piped Gas Explosion - Walls

5.4.1. The internal walls could fracture, possibly causing damage by fragments of concrete being blown into the space on the other side of the wall. This would occur to the walls directly either side of the location of the explosion, at whatever storey that occurs in the block.

5.4.2. Since these walls are the only vertical load bearing elements of the structure, it may be that they are sufficiently damaged to no longer take that load, thus allowing the walls and floors above to fall.

5.4.3. For all levels in a 4 storey block, the joints at the top and bottom of the internal wall could fail, possibly resulting in the wall being blown out as a unit in to the space next door, with subsequent collapse of floors and walls above.

5.4.4. The external (end) walls would fracture, possibly causing damage by fragments of concrete being blown out. As for the internal load bearing walls, it may be that they would be sufficiently damaged to no longer take load, with collapse above occurring.

5.4.5. The joints at the top and bottom of an external wall panel could fail at any height of the 5 storey block, causing the whole panel to be blown out and the structure above to fall.

5.4.6. The comment in Section 4.3.3. applies.

5.5. Other Explosion – Floors

5.5.1. If contrary to our recommendations, the piped gas is removed from the 4 storey blocks the reduced e.s.p. of 17kN/sq.m greatly reduces the potential damage although the floor units of the room in which the explosion occurred would probably still fail.

5.5.3. The floor units are particularly weak when taking load from beneath so again, floor units above the location of the explosion would also fail.

5.5.4. The comment in Section 4.3.3. applies.

5.6. Other Explosion - Walls

5.6.1. Under a load of 17kN/sq.m the internal wall slab themselves are most unlikely to fracture and their top joint connection would also remain intact. However, for the top two storeys, the joint of the wall at the base may fail possibly resulting in the internal wall being blown out as a unit in to the space next door, with subsequent collapse of floors and walls above.

5.6.2. As for the internal walls, the external (end) wall slabs themselves would not fracture but the connection at the top of the wall may fail at any floor level.

5.7. Summary

5.7.1. We believe that the BRE's 1987 recommendations effectively summarised the rigorous and well considered thinking which developed in the two years or so which followed the Ronan Point incident and as such we consider them reasonable and appropriate for appraisal of existing LPS buildings today. On that basis, the 4 storey blocks which have not been designed or constructed to avoid progressive collapse in the event of accidental loading do not need to comply with robustness requirements. Piped gas can stay and strengthening is not needed.

6. SUMMARY

6.1. Based on our studies, we believe that the 14 storey blocks do comply with reasonable robustness criteria although local damage would occur in the event of accidental load. Whilst regrettable, this is acceptable and, if still live, the piped gas supply need not be removed, nor is any form of strengthening work required. Similarly we consider that whilst progressive collapse is possible in a 4 storey block in the event of accidental loading, the extent of damage would not be considered as disproportionate and again therefore, no action need be taken.

6.2. Whilst we have not inspected the structure of any 7 or 8 storey block, we believe the form of construction within these units will be as found in the 14 storey blocks. We base this on the knowledge that at no stage since the Ronan Point incident has robustness requirements been considered unnecessary for 7 and 8 storey blocks. In due course a limited survey would prudent to check but we firmly believe that the designed strengthening in the 14 storey block has been included in all blocks over 6 storeys. We are unable to comment on the level of workmanship but have no reason to believe it to be any worse than for the other Jespersen blocks on the Estate.

6.3. Our work on the 5 storey (and by implication the 6 storey block) effectively confirms that they have not been designed or constructed to avoid disproportionate collapse in the event of accidental loading. This is contrary to what we believe is a reasonable criteria.

6.4. The above report is intended to inform the risk assessments necessary to consider the robustness of the large panel system blocks on the Aylesbury Estate. Whilst these assessments are intended to be useful in enabling the Council to decide its future strategy for the Estate, Alan Conisbee and Associates' recommendation remains that the gas should be removed from the 5 and 6 storey blocks with some strengthening also necessary to those blocks but no action is required on the 14 storey blocks nor on the 4 storey (or less) blocks. We believe that the BRE's 1987 recommendations effectively summarised the rigorous and well considered thinking which developed in the two years or so which followed the Ronan Point incident and as such we consider them reasonable and appropriate for appraisal of existing LPS buildings today.

6.5. Whilst we would not support a policy of merely removing the gas supplies and not strengthening, we accept that gas removal alone significantly reduces the risk of an explosion. We therefore recommend that it should be carried out as a matter of high priority, to be then followed by phased and well considered strengthening programme. We would also recommend that the HSE is notified of the current situation.

6.6. The principle of where strengthening is likely to be needed is detailed above but further design development is necessary to refine the proposals with a view to ensuring the work causes the minimum disruption to residents and is as economic as possible. In this regard, a close eye should be kept on the BRE's current work of full size testing of redundant LPS blocks. Alan Conisbee and Associates are partners with the BRE and other organizations in the industry progressing the PII (Partners in Innovation) government backed initiative. It may be that the results, if verified and authorized, have a bearing on the extent of strengthening needed at the Aylesbury Estate. It is almost certain that this work will not affect the recommendation that the piped gas should be removed.

6.7. It is considered good housing management policy to minimize the risk of bottled gas in buildings and, as applies to most LPS buildings regardless of height and robustness standard, a ban should be enforced.

6.8. The 5 and 6 storey blocks on the Estate should be checked for susceptibility to vehicle impact. This involves assessing whether it is reasonably possible for a vehicle to hit the building at some speed. If so, protective bollards should be installed. In view of the relatively low cost of such protection, the client may wish the 4 storey blocks to also checked for susceptibility to vehicle impact. The 14 storey blocks comprise insitu concrete for the first 4 storey so the risk of damage due to vehicle impact is negligible.