A review of a Crowd Safety Options Appraisal undertaken for Tottenham Hotspur Athletic Football Club Ltd.

Abstract

The joint authors of the appraisal were Movement Strategies, Populous and T.Spencer & Co.

The appraisal addresses the safety and comfort levels for pedestrians using Tottenham High Road at a location in the immediate vicinity of the ground; data and analysis that is provided is directed at establishing that the proposed design of the stadium development is the most appropriate. The core content of the appraisal concerns Hazard and Risk. This review interrogates the methods adopted by the authors in reaching their conclusions.

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October 9th 2015

Tottenham Hotspur Football Club - Crowd Safety Options Appraisal, [3]

1 Introduction

The commentary that follows examines the Movement Strategies study [3] concerning crowd safety issues relating to the feasibility and practicalities of retaining three listed buildings on Tottenham High Road namely, No. 746, No. 748, No.750, as illustrated in Fig.1.

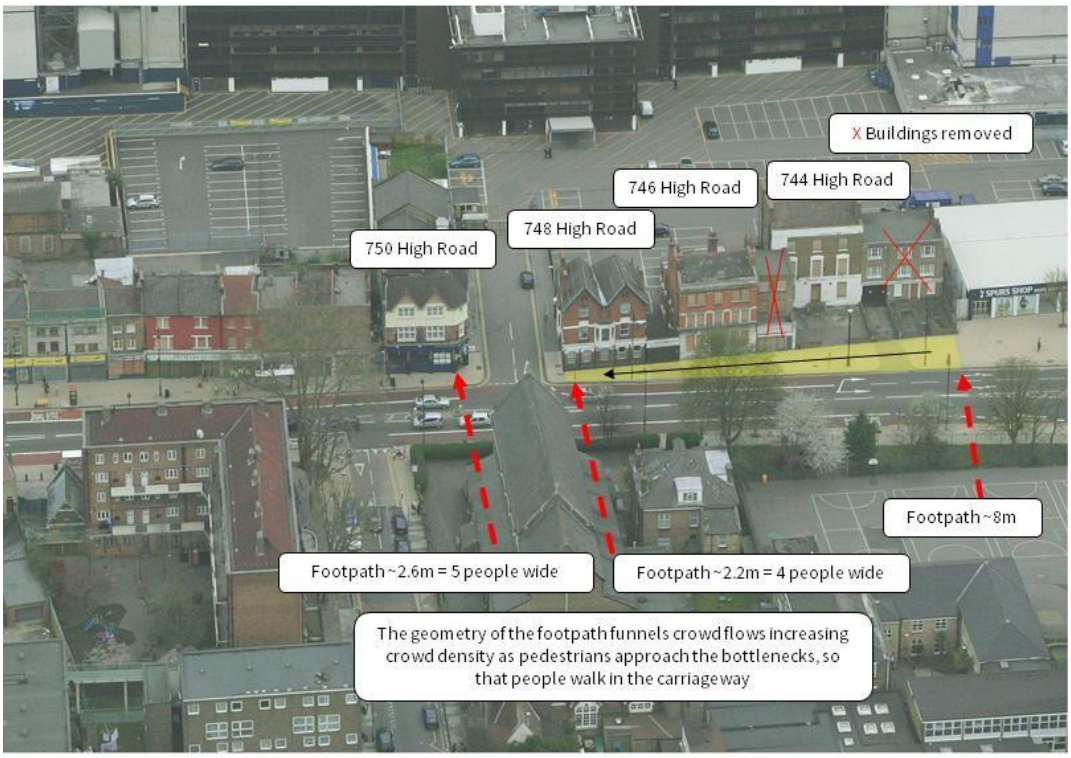

Fig.1. Properties and associated walkway widths, (from planning document [3]).

The Planning Statement stresses the significance of crowd safety issues.

'A key determinant in the design of the revised scheme has been the need to address crowd safety and crowd flow issues along the High Road. The issue is longstanding, but now better understood. The Club and its design team are obliged to put crowd safety at the top of their priorities and the design of the new stadium and its context provides the ideal opportunity to address this issue.'

In addressing the crowd safety issue the study undertaken by Movement Strategies, [3] adopts Levels of Service, **LOS**, as a means of assessing risk and considers ALARP (**A**s **L**ow **A**s **R**easonably **P**ractical) the defining consideration. This writer would define the analysis as restrained. As subsequently discussed the assumptions adopted provide a lower bound (a conservative answer with regard to safety) which is the correct approach when uncertainties are present.

2 Movement Strategies, Populous and Spencer study [3]

Necessary data pertinent to the safety of arriving spectators on match days and other pedestrians using the High Street on match days was obtained from analysis of video footage. Data obtained during a 90 minute interval prior to a match on May 16th 2015, is illustrated in Fig.2 which is taken from the report.

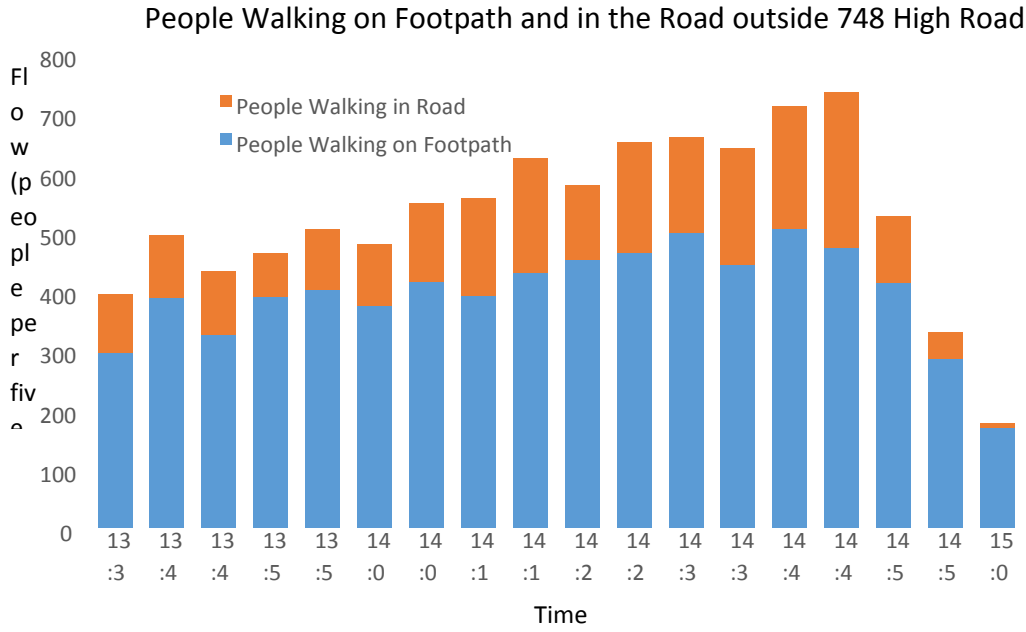

Fig.2. Typical video data as interrogated by Movement Strategies.

Where bulk arrivals from train and tube stations are present in a crowd flow the adoption of a five minute interval can mask their presence. The observed capacity of the walkway (effective width 1.8m in front of 748 High Road) appears to be approximately100 persons/minute which equates to 55persons/metre/minute, lower than might be assumed.

Fig.2 also informs that for 90min prior to match kick-off significant numbers of persons walk in the road.

Fig.3 Surveyed Movements at 748 High Road (2.2m wide)[3].

A hypothetical flow rate at each location was derived by summing both elements of flow (on-walkway + on-road) and dividing by the walkway width at each location. Fig.3 illustrates data from surveys outside of 748 High Road. Similar graphs are presented for 750 High Road and a location north of Paxton Road. As would be expected the walkway widths at the locations were reflected in the percentages observed walking in the road. The results from video surveys established that:

1. The proportion of people walking in the road increases as the flow rate increases.

This is predictable. A walkway has a capacity above which pedestrians whose clock is ticking will hurry and walk in the road. What is also important and noted by the report's authors is that the crowd is made up of groups, pairs and singletons. Groups walk more slowly and individuals in a moving stream inevitably seek to overtake; this is the reason why even at low flowrates individuals will step into the road.

2. Contraflows were effectively equal in the vicinity of 748 and 750 High Road.

The scatter about the trend line reflects the nature of the flow. In a uniform flow scatter would not be present in the observed data. The scatter is indicative of a variable density and slower moving groups. The presence of persons walking in the road at very low densities is important. A flow rate of 10 persons/metre/min equates to 10 persons walking in single file **6m** apart with a walking speed of 1m/s. The average walking speed is normally about 1.4m/s

The presence of persons walking in the road at such low densities indicate to this writer that should an individual choose to step into the road to avoid conflict he or she will not necessarily elect to step back onto the walkway once the conflict no longer presents itself. A conflict does not mean an actual impact. A conflict is any stopping, changing of direction or breaking of normal walking pace due to a too close confrontation with another pedestrian.

A pedestrian in a disordered contraflow will make rapid adjustments in their direction of travel to avoid collisions. Inevitably as the density of the flows increase the present walkway widths cannot accommodate lateral movement and individuals are forced into the road.

The *Guide to Safety at Sports Grounds,[1]*, known as *The Green Guide,* is acknowledged to provide definitive guidance on matters relating to spectator safety. It is noteworthy that a **basic design principle** therein is

'Smooth, unimpeded flow through an exit route is best achieved by ensuring that the exit system does not narrow along its length.'

Whilst the emphasis in *The Green Guide* concerns egress the basic principle is equally applicable here and the current walkway provision fails to recognise the principle.

2.1 Provision for walkway comfort and safety

With regard to providing for walkway comfort and safety the planning report adopts two definitive documents, Fruin [2] and guidance issued by TFL [4]. Both documents address pedestrian spaces using Levels of Service (LOS). This concept originates from the research of Fruin that provided the source of the referenced work [2].

There are no standards or documents that comprehensively address what this writer would describe as unconstrained pedestrian flow which describes the present case.

Adopting the principles that provide the basis for Fruin's ground breaking study [2] and TFL's extension of the work [4] has to be considered sound practice.

The capacity of a corridor, where flow is constrained, is readily defined; when demand exceeds the capacity the resultant queuing at the mouth of the corridor is a well-known safety hazard as is the resultant risk.

The capacity of a walkway is not readily defined as on a walkway a pedestrian can thinkingly or unthinkingly step into the adjacent roadway and as a consequence expose himself or herself to a risk from a moving vehicle.

The TFL guidance in part concerns retail environments which is a category Tottenham High Road would belong in.

The planning report authors[1] rightly describe the TFL guidance [4] as being more generous in terms of space than Fruin [2].

The present concern does not relate directly to retail activity nevertheless it is significant that TLF guidance states that

'In high street or tourist areas the (footway) width can be reduced to 3.3m if there is no street furniture (except street lights). This width allows two group to pass.'

Fruin describes SIX Levels of Service (LOS A- LOS F) whereas the TFL Pedestrian Comfort Guidance whilst adopting a similar approach attempts to be more precise.

The planning document [3] discusses in a comprehensive manner Levels of Service as considered by both Fruin and TFL documents.

Movement Strategies concluded from a consideration of Fruin [2] that the appropriate target to reduce risk to a reasonable level should be LOS A/B (if practicable) and otherwise LOS B.

LOS A (>3.3m^2/person) flowrate of 23 persons/metre/min or less.

LOS B (2.3 – 3.3m^2/person) flowrate of 23- 33 persons/metre/min

Allows for an individual to select normal walking speed and to bypass other pedestrians in primarily one directional flow. Minor conflicts will arise in contraflow and the Level of Service is considered appropriate in a busy space where recurrent but not severe peaks occur.

LOS C (1.4 – 2.3m^2/person) flowrate of 33 – 49 persons/metre/min

and is described by Fruin[2] as follows

'…freedom to select individual walking speed and freely pass other pedestrians is limited…'

' …..Designs consistent with this level of service would represent reasonably fluid flow, however, considerable friction and interaction between pedestrians is likely to occur , particularly in multi-directional flow situations. Examples of this type of design would be

[1] Throughout this document the term *authors* refers to the authors of the planning document

heavily used transportation terminals, public buildings, or open spaces where severe peaking, combined with space restrictions, limit design flexibility.'

2.2 The consented scheme

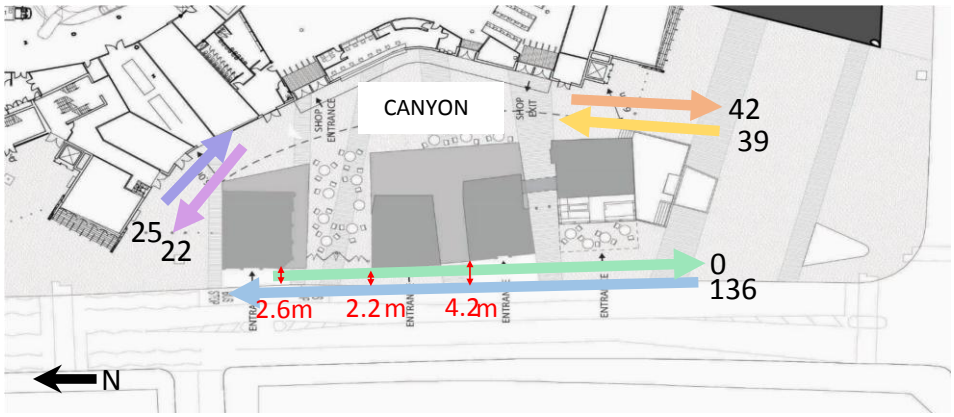

Fig.4. Forecast flows/minute in the consented scheme.[3].

Using the forecast flows illustrated in Fig.4 coupled with the effective widths the predicted flow at the 'pinchpoint' was derived as 76 persons/m/minute. The authors correctly conclude that this is not achievable given the composition of the spectator body and large numbers would inevitably walk in the road. Site data cements this conclusion.

The authors consider the possibility of diverting an element of the flow through the Canyon indicated in Fig.4.

TFL literature states

'....The current pedestrian traffic routes, walkways should be defined and evaluated as

*a) Do the pedestrian routes correspond to the **desire lines**?*

In this instance as recognised by the authors the desire line for persons approaching from the south will be the most direct line which the Canyon is not.

The authors present an ingress profile relative to time and focus on the fifteen minute interval prior to a week day evening kick-off; it is considered that 30% of the spectator population will arrive during this interval. During the 30 - 15min interval prior to kick off it is considered that 25% of the spectator population will arrive. It is assumed that the forecast flow rate of 185 persons/minute is derived from these assumptions. This is what was earlier referred to as a restrained analysis. The flow will not be uniform; there will be pockets of greater density and the assumption of a uniform flow will lead to an under estimate of actuality. As a consequence a restrained analysis resulting in an unacceptable solution correctly informs the designer as reality is more severe.

It is important to recognise as previously mentioned that flowrates derived from intervals greater than five minutes do not fully reflect the nature of bulk arrivals from a station should they be present.

Consider Fig.5 which illlustrates data concerning spectator arrivals at a sporting venue walking from a tube station. The tube station was approximately a 15min walk from the venue. The data was obtained using a minute interval count. The skyscraper characteristic evident in Fig.5 correlates with the arrival of tube trains.

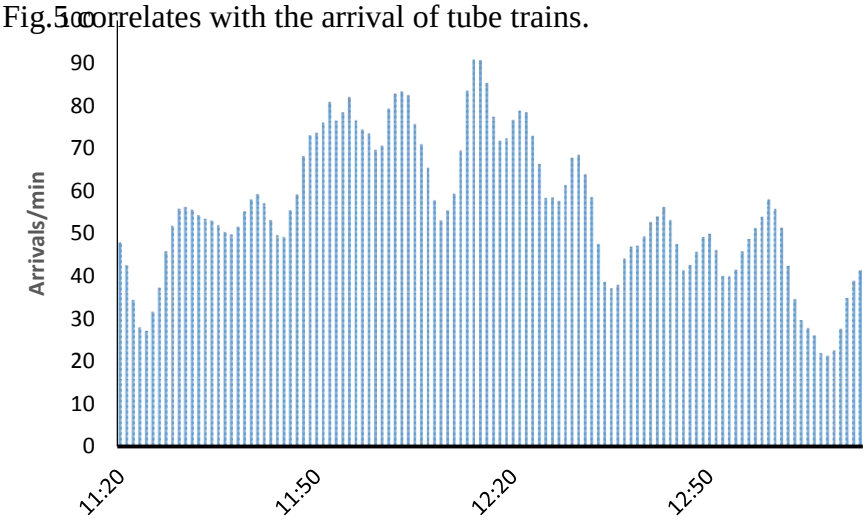

Fig.5 Typical characteristic of rate of spectator arrivals at a venue from a tube station .

This writer is not knowledgeable with regard to modal share of arrivals at THFC however the club website indicates that the walk from Seven Sisters tube station is 20min. Consequently for spectators using the tube there will be an element of bulk arrival. This creates a variable density in the flow in addition to that attributable to social groups.

There are commonly used and well understood expressions when describing egress following an event. 'Hard' finishes where all spectators depart immediately following final whistle and 'soft' finishes where spectators drift away prior to final whistle or depart slowly after the final whistle. A similar description for arrivals given the nature of the event from which the arrival data illustrated in Fig.5 would be a 'soft' arrival. For purposes of event management at the venue a 30min arrival plateau applied. It is apparent that peaks throughout the interval can be 20% greater that the design value.

The mid-week evening kick off has been adopted by the present scheme and using the foregoing terminology the match would create a 'hard' arrival.

Adopting Fruin, [2], the forecast Level of Service of the proposed scheme derived from a demand of 22 persons/m/minute is LOS A.

LOS B is considered to not create an unacceptable level of risk. LOS B allows for up to 33 persons/m/minute. A reasonable assumption would be that LOS A is conservative and LOS B could accommodate the likely bulk arrivals and variations in density due to social groups.

The forecast flow rate far exceeds the comfortable capacity of the present walkway which forces pedestrians into the road.

This writer considers that Movement Strategies conclusion that the consented scheme does not provide a reasonable level of safety is correct. With respect to safety there is a tenable argument that the assumptions adopted by Movement Strategies are conservative. Less conservative assumptions would add weight to their conclusion.

3 Alternative Options

The authors comprehensively consider 12 alternative options

1 The Consented Scheme with no crowd management.

An observer of recent stadium events in the Olympic Park would immediately dismiss this option. A primary egress route requires a diversion in the pedestrian flow of thirty percent. The absence of stewarding resulted in chaotic conditions due to spectators' desire line.

2 The Consented Scheme with barriers and stewarding and policing.

This option contemplates 100% of the crowd flow through the Canyon which is calculated to create a Level of Service C. Given the bulk arrival characteristic pockets of LOS D will be present and critical densities resulting in temporary stoppage are likely. In apparently removing one hazard, stepping into the road by large numbers of spectators, a hazard that creates a greater risk would be created. As is noted in the report an increased use of the western walkway will occur. Traffic speeds will increase and small numbers of pedestrians on the western walkway will 'jump' barriers to cross the road. TFL fatality statistics clearly demonstrate the level of risk associated with a manoeuvre of this nature.

Correct route geometry provides for an acceptable level of risk. Temporary barriers can be removed and knowledgeable spectators can and will circumvent the intentions of police and stewards.

The likely increase in numbers of spectators crossing the road in moving traffic streams creates an unacceptable level of risk.

3 Consented Scheme with temporary closure of the Southbound Bus Lane.

The operative word is temporary. A closure in excess of 60min., prior to kick off would be necessary. If Fig.5 of the authors' report is considered in conjunction with their Fig.15 a 90min closure would be necessary to prevent pedestrians moving into the road. Again using the stadium events in the Olympic Park as an example

Prior temporary closure – reopening – end of event closure of a relatively quiet road with a bus route was quickly dismissed as impractical.

4 Consented Scheme with Permanent Closure of the Southbound Bus Lane.

The forecast flow creates a LOS B with the associated risk of conflict. It is not clear to this writer as to whether the kerb and lack of continuity in level of the road surface has been included in deriving an effective width. If this is the case then the Level of Service will approach B/C. In either case given the ALARP requirement this option is not, as clearly stated by Movement Strategies, acceptable.

5 Consented Scheme with temporary Closure of Both Southbound Lanes.

The factor that negate this option is that given when considering Option 3.

6 Consented Scheme with temporary Closure of oth Southbound lanes and Contraflow on Northbound carriage.

The factor that negate this option is that given when considering Option 3.

7 Consented Scheme and Move High Road Westwards.

Whilst the writer is not competent to assess this option overall it is difficult to envisage the cost benefit equation resulting in a positive outcome

8 KSS Consented Scheme and Shared Surface on High Road.

The study considers that the option is not feasible on a match day. TFL statistics relating to fatal pedestrian vehicle accidents indicate absence of daylight and alcohol as significant risk factors, both are present here.

9 Consented Scheme and Tunnel the High Road.

Movement Strategies succinct conclusion based on deliverability is correct.

10 Consented Scheme and Flyover.

Conclusion regarding disproportionate benefits is indisputable.

11 KSS Consented Scheme and Pedestrian Bridge/Walkways.
12 Consented Scheme with Extended Podium.

Both options as noted by Movement Strategies are contrary to spectator' preferred choice of route. The present safety issue with the associated level of risk will remain.

With regard to the foregoing options it is important to recognise that a solution has also to address daily use. The consented scheme does not satisfy the TFL requirement concerning minimum walkway width which is 3.3m.

13 The Populous Scheme.

An Option Appraisal Summary is presented within the report that adopts crowd safety, traffic and highway and deliverability as primary criteria for acceptance. The Populous Scheme is considered to be the only option to satisfy all three criteria.

The question that quite properly should be addressed is -

What are the reasons that the consented scheme is no longer considered to be sound?

Recently developed areas of knowledge and understanding of hazards and their associated risks as applied to crowded areas were compartmentalised during the development of the scheme.

A risk is the chance that a hazard will actually cause someone harm.

The fourth edition of the Guide to Sports Grounds (1997) raised awareness that

'Absolute safety however desirable in theory is in reality, unattainable'

Architects and engineers began to quantify risk associated with crowded places.

Experts trained and experienced in risk assessment have become more successful in communicating with other professions about how they assess health and safety issues.

Consequently two factors are now established within professions involved in designing and managing major venues when defining level of risk namely Severity and Probability.

London 2012 brought to the attention of stadium operators and designers their responsibilities as regards the Last Mile alternatively known as the Grey Space outside of a venue.

The withdrawal of police from traffic management.

Whilst in this instance it can be argued on grounds of probability that the historical evidence indicates a low level of risk is present the severity of the risk associated with the consented scheme is catastrophic and therefore not acceptable.

CONCLUSION

The method adopted by Movement Strategies in the Crowd Safety Options Appraisal to identify the hazard related to walkway width and pedestrian flow is considered to be sound. The level of risk associated with the hazard, pedestrians being forced into a road, is not acceptable on the grounds of severity. The Populous design addresses the risk.

REFERENCES

1. DCMS *Guide to Safety at Sports Grounds.* Fifth edition 2008
2. Fruin J. *Pedestrian planning and design* 1971 Elevator World 1971
3. Movement Strategies, Populous, Tim Spencer & Co. Appendix C Planning Statement.
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4. TFL *Pedestrian Comfort Guidance for London* Guidance Document 2010.

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The author's experience over a 30 year period relating to crowd movements and attendant safety issues embraces numerous major venues such as Wimbledon, Aintree, Ascot, London 2012 and Manchester United FC. Extensive studies relating to large scale retail developments such as Liverpool One and Leeds Trinity Square have been undertaken. He has made major contributions to National and European safety documents such as *The Guide to Safety at Sports Grounds* and *EN 13200-Spectator facilities.*