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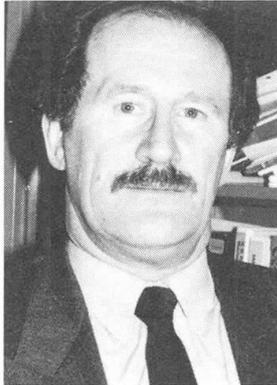
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## Effect of Design on Crowd Safety and Calculation of Safe Capacity

Influence du projet sur la sécurité du public et capacité d'un stade  
Entwurfseinflüsse auf die Zuschauersicherheit und Stadiumskapazität

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### SUMMARY

Design, redevelopment and assessment of stadia must consider crowd movement, control and safety. In addition to location, type of accommodation, nature of the events and capacity, other areas must be addressed. Operation of the stadia has to include ingress, viewing and movement during the event, egress and emergency evacuation. Safe capacities must be calculated, taking into account existing conditions, the nature of the event and the effect on spectators, particularly their need for movement.

### RÉSUMÉ

Le projet, la réhabilitation et l'évaluation des stades doivent tenir compte du mouvement, du contrôle et de la sécurité des masses humaines. Outre la situation, la nature et la mise en place de la manifestation et la capacité du stade, il faut aussi considérer le contrôle des spectateurs pendant leur entrée dans le stade, leur sortie normale ou leur évacuation d'urgence, tout comme pendant la durée de l'évènement. L'auteur expose les moyens de déterminer avec sécurité la capacité du stade, en fonction des conditions locales, de la nature de la manifestation et du besoin de mouvement des spectateurs.

### ZUSAMMENFASSUNG

Der Entwurf, die Erneuerung und Beurteilung von Stadien muss die Bewegung von Menschenmassen, ihre Lenkung und Sicherheit einbeziehen. Neben der Lage, Unterbringungsweise und Art der Veranstaltung sowie des Fassungsvermögens ist die Kontrolle der Zuschauer beim Betreten, Verfolgen der Veranstaltung, Verlassen der Anlage und bei Notevakuierung zu beachten. Der Beitrag behandelt die Ermittlung der sicheren Personkapazität auf der Basis vorhandener baulicher Randbedingungen, der Art der Veranstaltung und ihrer Wirkung auf die Zuschauer.



## 1. DESIGN OF SPORTS STADIA

From an engineering aspect, in the designing of any building or structure, the first steps are to establish a brief and ascertain the likely loading conditions. The same principles apply in the designing of a sports stadia ie. by establishing the operation of the stadia the loading conditions and design criteria are established.

Although sports stadia are designed in theory for the holding of sporting events, in many ways their main function is the accommodating of spectators, frequently in very large numbers. Whether the stadia is an existing one, an existing stadia subject to major redevelopment, or a newly designed stadia, with regard to spectators they must allow for:- ingress, viewing and movement during the event, and exiting (both normal and emergency).

Although these criteria appear self apparent, the legislation and Guides which control stadia design and assessment were only introduced and developed as a direct result of disasters. In the main three:- Ibrox - 1971 [1], Bradford - 1985 [2] and Hillsborough - 1989 [3].

The initial legislation itself [4] followed the Ibrox disaster as did the original Guide to Safety at Sportsgrounds (The Green Guide) [5]. Of the subsequent editions of the Green Guide the major revisions followed the incidents at Bradford and Hillsborough.

One of the main problems that has occurred over the years in developing the editions of the Guide as a basis for assessing safe capacities of sports stadia, are the continued statements that "we have never had an incident".

The tendency is always to concentrate on past incidents rather than looking for the potential for hazardous situations which may cause further incidents, which must be the way forward. That is not to say that we are advocating absolute safety or that stadia are dangerous. Where crowds of spectators, in the order of say 30,000 are gathered, it is unrealistic to look for absolute safety but it must be recognised that there are potential dangers. What can be established are conditions which allow spectators to enter, view and move during the event, and exit in reasonable safety.

### 1.1. Ingress

The initial element of ingress is the means of gaining admission and the flow into the ground will be controlled by the nature and design of the turnstiles, the method of payment ie. all tickets, cash payment etc and the skill of the operator. Such arrangements will dictate the likelihood or otherwise of queues of spectators building up. Although this is not necessarily within the precincts of the ground, consideration must be given to the safety of spectators forming such queues.

The flow rate through the turnstiles should be commensurate with the flow rate that is possible via the ingress routes to the desired viewing positions. Care should be taken that on these routes franchise outlets, toilets etc do not in anyway obstruct the route or generate queues which could obstruct the routes. Wherever possible such facilities should be barriered off in an area to one side of the route, such barriers should be designed and arranged to prevent excessive pressures building up in the queues or in spectators flowing past.



Wherever possible the turnstiles should have a direct link to the viewing area without crossing over other movement routes and should be clearly signposted to the viewing positions, facilities, franchise outlets, toilets etc.

Clearly the point of access to the precincts of the stadium should be as close as possible to the appropriate viewing area and in the design or alteration of new stadia this is an essential element to be taken into account in the initial stages of design.

### 1.2. Viewing and movement during an event

Unobstructed viewing for all spectators, whatever their physical build, is essential if pressures and turbulence are not to be created by spectators straining to see the event. Where a viewing area does not provide a full view of the event it should be discounted from the calculations in assessing capacity, and be kept out of use during the course of the event. Spectators should also be able to leave and regain their viewing position during the course of the event.

Considerable debate has taken place over the years with regard to crush barriers on standing terraces, in particular with regard to their strength and spacing. With regard to their strength, they are to be designed or tested to ensure they are fit for purpose. That is to say they will not fail under the forces to which they may be subjected during the course or at the end of an event. The figures quoted within the Guide to Safety at Sportsgrounds are based on an assessment of what surging pressures a body can be subjected to without sustaining injury (documentation on these tests is available). With regard to spacing, the distances stated in the Guide are those over which such forces can be generated.

### 1.3. Egress

Whatever the theory with regard to egress, experience has shown that at the end of an event, particularly a football match held at a major ground within a town centre, virtually all of the crowd endeavour to leave immediately on the final whistle. Therefore the exit route must be designed to cater for such a situation. Similarly the egress route should be capable of dealing with emergency evacuations, either by the normal egress routes alone or by those routes in conjunction with extra emergency arrangements.

The calculations for exiting are based on the speed of movement of the crowd (flow rate), the limiting width of the exit route and the acceptable evacuation time.

The evacuation time is the time taken for all spectators to leave the viewing area and pass through any element of the exit route. The maximum time is 8 minutes but this may be reduced based on prevailing conditions ie. to a minimum of  $2\frac{1}{2}$  minutes from a timber stand. Interpretation is advocated based on an assessment of the potential hazard ie. fire etc.

It is essential that spectators only gain access to the egress route at a flow rate commensurate with that at which they can flow through the entire route to exit from the ground. Suitable barrier and restrictor arrangements should be placed at the exit from the viewing area to provide a smooth and controlled flow. It is also desirable that egress routes lead directly wherever possible to the final exit from the ground and do not cross other exit routes. As with ingress routes, where exit routes combine this should be arranged in a smooth manner and due account taken of any narrowing that may occur at such



junctions when establishing the limiting width of the exit route.

## 2. CALCULATION OF SAFE CAPACITY

### 2.1. What is safe capacity?

The safe capacity of a stadia is the summation of the safe capacities of the individual viewing areas of the stadia. For each area that being the lesser of the figures calculated by assessing:- ingress, viewing and exiting, based on the prevailing conditions at the time of the assessment. It is not acceptable to take into account proposed future works, should improvements etc be undertaken following the assessment of safe capacity, a re-assessment should then be undertaken to establish whether such works have provided conditions which will allow an increase in the capacity.

### 2.2. Factors to be taken into account when calculating safe capacity

2.2.1. **The prevailing conditions** - As stated these are the conditions that exist at the time of certification. In many respects this is the area where the application of professional judgement by those undertaking the assessment is the key factor. Ie. where underfoot conditions are such that tripping hazards are created the judgement must be made as to whether they are such that spectators should not be allowed to view from or move over such an area. If this is the case it should be fenced off and taken out of use and out of the calculations. Alternatively a reduced density may be acceptable to enable the area to remain in restricted use and a commensurate limitation placed in the calculations. Similarly where elements of the ground, such as walls, offer a potential hazard, particularly if subjected to pressures from the crowd, a decision must be made as to whether the area can be used at all or could be occupied or used on a limited density basis.

2.2.2. **Constraints dictated by the construction and location of the ground** - This takes into account the actual location of the ground, for instance its connection to the public highway ie. spectator access points. If it is only possible to gain access to the stadia from one side there will be a need to provide routes for access and egress to traverse the stadia to the various viewing areas without creating crowd disruption and confusion. The formation of such routes may well limit the capacity of the ground unless considerable work is undertaken. Similarly if direct access is not possible to individual viewing areas then controlled sub-divisions may be required at various locations on the route.

2.2.3. **Testing** - To some extent testing of barriers has been dealt with earlier, although testing is not simply limited to barriers it is required for any element of the ground which may be subjected to pressures from the crowd, the strength of which cannot be readily determined. This would include handrails, walls and the like particularly on the exit routes. The undertaking of such testing is essential to enable a proper assessment as to whether that element is fit for purpose, or as to whether any restrictive factors should be taken into account in the calculation of the acceptable capacity. This is more readily apparent for crush barriers on terraces but where it occurs within the entry or exit routes there may well be a need for the exercising of professional judgement as to what the appropriate limitations should be.



**2.2.4. Crush barrier spacing** - The recommendations contained within the Guide to Safety at Sportsgrounds are based on considerable studies and research and although a degree of flexibility is acceptable the principles must be adhered to if a safe condition is to be achieved. Non compliance will result in a reduction in available viewing area and therefore a reduced capacity.

**2.2.5. Maintenance** - Once the assessment and the safe capacity of a ground has been established it is clearly necessary to maintain the ground to at least the standard at the time of certification. Should the ground be allowed to deteriorate this would in effect be a breach of the conditions of the certificate and, particularly if an incident occurred, the club could find itself in a very serious situation. Should the local authority become aware of such a deterioration, a reassessment of the ground should be undertaken and a commensurate reduction in the acceptable capacity established. The certificate should then be amended accordingly.

Over the years inspections of grounds have shown that many problems do arise due to a simple lack of day to day maintenance. The Guide does recommend local inspection of the ground after an event, this is to establish whether any damage or defects have developed which should be rectified prior to the next event.

**2.2.6. Future improvement/upgrading** - The benefits of establishing a longer term strategic development plan for a stadia are self evident. The club can invest in its ground commensurate with its needs available finance or wishes to increase the safe capacity. Clearly a club in a lower division may well be content with a restricted capacity but on promotion would quite probably wish to increase that capacity and must therefore have plans for development in place to achieve this. A long term strategic plan would also mean that any investment was made in the most beneficial manner and with a clearly established long term objective.

**2.2.7. Controlling and monitoring capacity** - It is also essential that the actual capacity of the ground, and the distribution of the spectators, on an event day does not exceed the capacities stated within the certificate. Therefore suitable monitoring/counting systems together with a spectator distribution system which controls movements to the appropriate viewing areas, are essential. Without these the whole principle of certification fails to be effective. Where such monitoring and control distribution systems do not exist, or are not considered adequate, there may well be a need for a further reduction in the stated capacity so that any broadbrush assessment or minimal controls would still ensure a reasonable and acceptable standard of safety.

**2.2.8. Stewarding and CCTV** - However well designed the stadia, during the event itself there is no substitute for a properly set up management team. Properly trained stewards are essential and when coupled with a strategically distributed CCTV system should enable effective crowd management.

### 3. SUMMARY

In the limited time available it is not possible to go into detail on the development of the Guide or its objectives, these principles however are set out within the body of the Guide. What has become apparent over the years with the development of this document is that all of the legislation and the various editions of the Guide are



disaster led. All too soon after an incident the promised good intentions to undertake reviews and enforce changes are forgotten. It appears sometimes that the industry wishes to be legislation led and will only make the moves forward that are clearly necessary, when the requirements are imposed on them.

I have endeavoured to set out the basic parameters on which the legislation was based and the Guide developed initially and subsequently revised. The objective never has been to attempt to achieve absolute safety, clearly that could not be practical. However over the years we have become totally convinced that it is possible to make a calculated assessment of a ground and establish capacities which can be accommodated with reasonable safety in designated areas. It is not the Guide or the Legislation which create safety, it is the correct application/interpretation etc of the information available coupled with the application of professional judgement by those designing, managing and certifying the grounds. Followed by adherence to the conditions/restrictions of the certificate when the ground is in operation.

In the past, when an incident has occurred, the main objective seems to be to allocate blame rather than identify the actual cause. At Bradford and Hillsborough sufficient information was contained within the Guides in use at the time to have at least identified the potential for the incidents. Appropriate action to deal with such matters when identified would go a long way to either avoiding them or at least greatly reducing their catastrophic effects. Until full and realistic appraisals are made of grounds in line with the parameters laid down in the Guide, and other guidance which is available, are applied objectively together with a full professional input, there will always be a potential for such incidents.

What is proposed is an objective engineering based approach using professional judgement and flexibility to produce an acceptable standard of safety.

#### REFERENCES

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3. HILLSBOROUGH - The Hillsborough Stadium Disaster 15th April 1989 - Inquiry by The Rt Hon Lord Justice Taylor - Final Report January 1990.
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