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Safely home

Win, lose or draw – how maths helps everyone to get home safely

In the FA Cup final they'll be 90,000 people moving through the transport system towards Wembley Stadium for a two-hour event, and then back again.

Wembley has an excellent safety record and that's because they understand crowd risks. As soon as you introduce crowds it's about risk management, and mathematical models feature very heavily in all of these concepts.

The concept of a square metre and people per square metre 'crowd density' is very important, and one of the best ways to illustrate that is a grid-based model.

So the principal is 4.7 - 5 people per square metre is your upper limit, when it gets to about four people per square metre you then need to have your controls in place.

Here we have Euston Station. Match day you would expect 1, 2 people per square metre. As they move down onto the tube the density increases. The crush-loading on a tube will be about eight people per square metre, that's on the train itself.

A static crowd can have a higher density because people don't extend their arms and legs. When the crowd's moving it needs to walk, so you need that space.

We have timelapse images of Wembley Olympic Way. They're coming in in train loads, there's a steady flow here so this is no more than two people per square metre.

Now as they're leaving of course, they're leaving at a stadium load. Some 30 - 40,000 people, moving down to Wembley Park station. And we'll see the losing team come out first, the winning team are encouraged to stay back with a lap of honour. This helps crowd segregation.

We're seeing a line of horses now creating effectively like lock gates, allowing a batch of supporters through at a time.

So here we see that lock gate operation, it's a different match but we see it from a different angle. Crowds flowing through the police line, the horses hold the crowd back, and then they allow the crowd to flow through again. This is just to regulate crowd density on the platform at the station.

Between the horses and that lamppost, this is about 20x20 square metres. So four hundred square metres in that area, and I'd estimate there's round about 2,000 people in there; two thousands divided by 400 that's round about five

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people per square metre. Very safe in terms of that context, it's certainly not crush density.

The only safe environment is when there's nobody there whatsoever. So it's understanding risk and managing those risks accordingly.