

A Quantitative Approach to Determining Inclusive Design Features Within UK Railway Depots

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ABSTRACT

Inclusive design is fast becoming a talking point for engineers, ergonomists, and designers. With holistic views on accessibility and inclusion in railways at the forefront of modern-day design and culture, it is a novel concept which could drastically change how we live and work. However, despite common interest in pursuing inclusive design strategies for railway passengers, there are significant gaps in inclusive thinking for railway workers – namely those who work in depots and trackside. Despite reforming modern system safety techniques, 2022 saw a significant increase in workforce injuries and little to no assistance in returning to work post-injury (Johnson, 2023). Limited accessibility and manoeuvrability in railway depots and trackside sees a workforce of injured staff unable to properly return to their original place of work and having to re-train in a less demanding sector.

In response to this, this paper presents findings and methodologies for quantifying the inclusiveness of depot design from a user-centred approach. The data captured emulates how staff experience working in train maintenance and what aspects could be improved to encourage inclusivity in the workplace whilst enabling staff to work to their highest potential. It is hoped that this research could reduce bias in quantifying inclusive design elements in depots, framing a new scope for what is deemed ‘accessible’ or ‘non-accessible’ to make railway depots a better working environment for all.

KEYWORDS

Train 1, Depot 2, Inclusivity 3

Introduction

Inclusive design is an element that wholly encompasses all users irrespective of ‘age, gender and disability’ (Inclusive design hub, 2021). The user-centred design approach allows ergonomists and design engineers to align their work with user requirements through all design stages, bettering work at every stage in the design process.

In a climate where ‘over 1 billion people’ (World Health Organisation, 2020b) have a long-term disability and ‘almost everyone will temporarily or permanently experience disability at some point in their life’ (World Health Organisation, 2020a), inclusivity should be at the forefront of engineering concepts and railway design. However, despite the ever-modernising

railway infrastructure, innovative, inclusive design is prioritised for Network rail’s ‘taxpayers, customers and passengers’ (Network rail, 2019).

With the construction of some railway depots dating back to Victorian times, there is little consideration for inclusive design in depots, leaving many workers to feel excluded and unemployable as the already ‘narrow specification of an *‘ideal candidate’* immediately discounts many disabled people’ (Libby, 2019).

However, what happens when a non-disabled member of staff injures themselves?

Many depot workers lose their lives or become severely injured whilst at work (Cant, 2012; Laskow, 2018), and, with little-to-no accessibility or inclusive design elements within railway depots, they are unable to return safely to their workplace (Glasswall, 2007; RAIB, 2007b, 2007a, 2007c, 2020, 2021; Office of Rail and Road, 2018; Spence, 2019; Stewart and RSSB, 2019; Horgan, 2020; Pitt, 2020; Bradshaw, 2021; Iosh, 2021). Because of this, ‘safety inspectors are demanding Network Rail implement “real change”’ (Topham, 2020) to minimise the fallout of inadequate conditions that railway workers face, reducing the unemployment of disabled workers and increasing the working potential for those who attain a life-changing injury whilst at work. Whilst the ideology of inclusivity is a broad concept, there is a spectrum of ailments to design for, whether the situation is permanent, temporary or situational, as denoted by the persona spectrum in Figure 1.

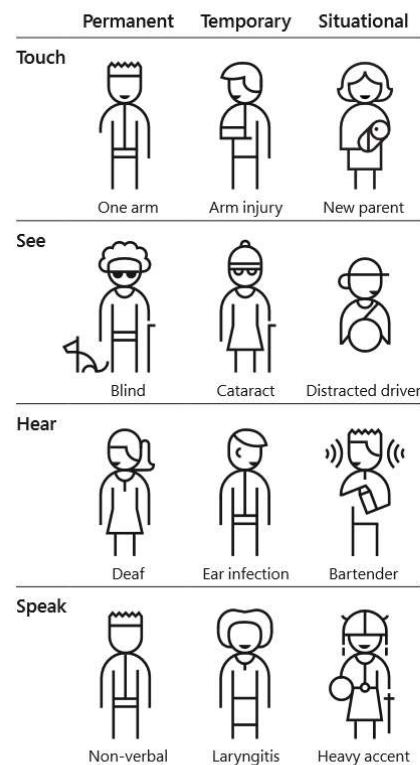


Figure 1: The persona spectrum – identifying permanent vs situational disabilities (Human Machine Interface Expert, 2017)

Inclusive design is perhaps the most up-and-coming trait of design engineering in rail. Now, in an ever-inclusive and all-involving world (Network rail, 2015), exclusivity should be a thing of the past. Today sees a new league of railway workers, including women, non-UK-natives, the disabled and the elderly, coming together in unison to form a vast and multifaceted workforce (Gillham, Thomas and Jake, 2021).

The risk of injury for those who work in railway depots is ‘irrefutable but should not be inevitable’ (Cortes, 2021). The implementation of faster trains, higher voltage electricity and ‘powerful machinery combines to make modern depots potentially deadly places to work.’ (RailEngineer, 2021). This is further compounded by the ‘growing number of vehicles on the network, leading to mounting pressure on operators and a desire to achieve ‘pitstop style’ servicing’ (RailEngineer, 2021). Although staff are hired and trained to a competency level deemed adequate by the ORR (office of rail and road), often they must complete a fitness regime which encompasses mental fitness, medical fitness, and physical fitness. These are defined as:

- Physical fitness: an individual ‘possesses the physical attributes of strength, agility etc., enabling the activity to be performed competently and safely’ (Cleeton, 2011).
- Mental fitness: ‘implies that no existing mental conditions may adversely affect concentration, decision making or behaviour, and so compromise competence and safety’ (Cleeton, 2011).
- Medical fitness: ‘covers any medical condition that may adversely affect competence and safety at present or in the future’ (Cleeton, 2011).

As companies are legally not allowed to discriminate against an individual in the workplace, they ‘should consider whether activities can be adapted to enable those with physical or medical limitations to work’ (Cleeton, 2011). Not doing so creates ‘unfair barriers for employment’ (Cleeton, 2011), reducing the intake of new employees and disallowing injured employees to continue their employment.

Despite rail staff retaining injuries from the workplace, many employees find themselves unable to return to work after their accident due to the inability to operate machinery or mental health concerns. Staff have gone to press stating that ‘Network Rail [have] not adequately addressed the protection of track workers’ (Horgan, 2020), adding, ‘we [are] being asked to work in incredibly unsafe conditions... my accident could have been prevented’ (Castle, 2021). Furthermore, although lessons learnt from accidents are recorded to be prevented, few design iterations are made in response to incidents, meaning that those who have suffered a life-changing injury cannot return to the same pre-accident workplace.

The Approach

After preliminary research and discussions with railway workers about issues they face with accessibility in the workplace and returning to work after an injury, a questionnaire was formed to determine the most significant factor affecting their ability to do their job. Train operating companies, management and depot workers were interviewed on what they felt were the essential aspects of depot design to provide an inclusive environment. This created a list of attributes about which to ask employees.

The work was sent to railway depot workers in the UK to capture representative information via an online survey. In the survey, workers were asked to rank the importance of different inclusive design features concerning how significantly not having them would impact their job. Data was compiled, and participants were re-interviewed to discuss any concerns regarding their findings in the depot.

Once the data was collected, it was ranked and given a relative importance statistic so that analysis of depots could be undertaken as a ‘tick box’ style exercise for depot designers.

Findings

This research found that staff value toilets, bright light working conditions, clear walkways and washing facilities over better coffee machines, mental health assistance and paid breaks. Despite the preliminary research branching into accessible design solutions for those injured at work who cannot return, findings showed a significant issue with current infrastructure and non-injured workers.

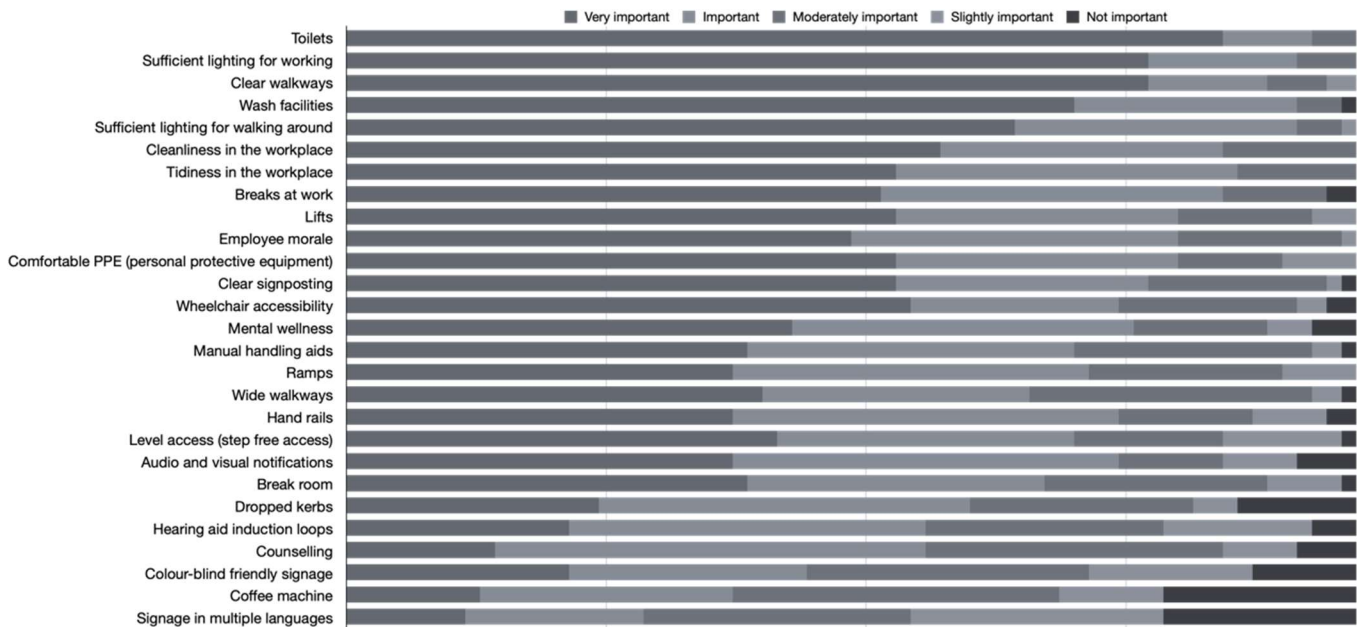


Figure 2: Graphical representation of votes cast against inclusive importance factors.

Workers value toilet facilities in the workplace far above any other characteristic in depot design. By contrast, the least essential attributes in creating an inclusive environment, according to depot workers, were multiple language signing, coffee machines and counselling.

Interestingly, feedback from the industry places coffee machines and multiple-language signposting as equally unimportant. Despite the employment of ethnic minority workers, multiple language signposting is not valued highly and was deemed the lowest in terms of importance. This could be, in part, due to a smaller percentage of ethnic minority staff members or due to the inability to reach out further due to the pandemic limiting social interaction.

Data extraction

Data captured from the questionnaire enabled qualitative analysis of depot inclusivity but did not provide the ability to analyse depots quantitatively, thus making the study susceptible to bias by personal interpretation; extracting the data from the questionnaire and mapping the feedback to a quantitative figure provided the basis for analysing depots quantitatively and minimalising the risk of error or miss-elucidation.

A matrix was drawn to deduce quantitative data from the results, giving the results from the questionnaire a score; 1 to 5, in conjunction with the importance spectrum in the questionnaire. The resulting matrix was designed whereby the qualitative result *Very important* was given the integer 5, and the lowest end of the spectrum was given the integer 1 for *unimportant*.

The matrix was then fitted to the data from the questionnaire, which provided a score, out of a possible 340 (68 participants providing a score out of 5 points per item), for the importance rating of inclusive aspects of depot design.

To quantify any future depot designs in respect to their inclusivity, data from the questionnaire was quantitated, and then, a weighting factor was produced using the ratio of importance against total possible importance.

‘Statistical weight is an amount given to increase or decrease the importance of an item’ (Glen, 2019). In this instance, the importance of an inclusive aspect could be calculated by dividing the total possible score of importance by the actual score of importance.

Results from inclusive design questionnaire (decending order)

Question	Total score for inclusivity	Amount of votes					Weighting factor	Weighting factor * 10	Score out of 10 for weighting factor
		Very important	Important	Moderately important	Slightly important	Not important			
Toilets	328	59	6	3	0	0	0.96	9.65	9.6
Sufficient lighting for working	322	54	10	4	0	0	0.95	9.47	9.5
Clear walkways	318	54	8	4	2	0	0.94	9.35	9.4
Wash facilities	315	49	15	3	0	1	0.93	9.26	9.3
Sufficient lighting for walking around	312	45	19	3	1	0	0.92	9.18	9.2
Cleanliness in the workplace	303	40	19	9	0	0	0.89	8.91	8.9
Tidiness in the workplace	301	37	23	8	0	0	0.89	8.85	8.9
Breaks at work	295	36	23	7	0	2	0.87	8.68	8.7
Lifts	294	37	19	9	3	0	0.86	8.65	8.6
Employee morale	293	34	22	11	1	0	0.86	8.62	8.6
Comfortable PPE (personal protective equipment)	292	37	19	7	5	0	0.86	8.59	8.6
Clear signposting	292	37	17	12	1	1	0.86	8.59	8.6
Wheelchair accessibility	288	38	14	12	2	2	0.85	8.47	8.5
Mental wellness	278	30	23	9	3	3	0.82	8.18	8.2
Manual handling aids	276	27	22	16	2	1	0.81	8.12	8.1
Ramps	275	26	24	13	5	0	0.81	8.09	8.1
Wide walkways	274	28	18	19	2	1	0.81	8.06	8.1
Hand rails	273	26	26	9	5	2	0.80	8.03	8.0
Level access (step free access)	272	29	20	10	8	1	0.80	8.00	8.0
Audio and visual notifications	271	26	26	7	5	4	0.80	7.97	8.0
Break room	271	27	20	15	5	1	0.80	7.97	8.0
Dropped kerbs	244	17	25	15	3	8	0.72	7.18	7.2
Hearing aid induction loops	242	15	24	16	10	3	0.71	7.12	7.1
Counselling	240	10	29	20	5	4	0.71	7.06	7.1
Colour-blind friendly signage	225	15	16	19	11	7	0.66	6.62	6.6
Coffee machine	206	9	17	22	7	13	0.61	6.06	6.1
Signage in multiple languages	189	8	12	18	17	13	0.56	5.56	5.6

Table 1: Creating a weighting factor using data from the questionnaire

The weighting factor was calculated as a whole integer instead of a percentage, as research suggests that percentages can be misleading because it is ‘hard to know if the percentage was calculated using the original numbers or the total resulting from the change’ (Krause, 2017). Secondly, they were calculated as a whole number for ease of addition when adding together the inclusive aspects of a depot during the analytic phase of the research.

Results – how we can use this in the future

Feedback from the questionnaire enabled a qualitative study to be evaluated quantitatively, allowing a hierarchical study of the most important aspect of inclusive design against inclusive design elements that perhaps were not as important. Results showed that toilets were deemed the most crucial inclusive design product, with coffee machines being one of the least important. With this, the results were weighted using a statistical weighting factor which determined the worth of every piece of inclusive design in the questionnaire.

A handful of depots were picked for demonstrative purposes, and it was determined that the least inclusive depot was Aylesbury (at 36%), with the most inclusive being Hitachi's depot in three bridges (at 66%). Hopefully, this method could be applied to depots throughout the UK to create a tolerable and intolerable region for inclusion, justifying expenditure for bettering rail depots with cost-benefit analyses and user-centred design iterations.

Name	Weighting factor /10	Aylesbury Maintenance depot	Northumberland Park Depot	Three bridges depot	Stoke Gifford depot	Slade green depot
Toilets	9.6	✓	✓	✓	✓	✓
Sufficient lighting for working	9.5	■	✓	✓	✓	✓
Clear walkways	9.4	✓	✓	✓	✓	✓
Wash facilities	9.3	■	■	■	✓	■
Sufficient lighting for walking around	9.2	✓	✓	✓	✓	✓
Cleanliness in the workplace	8.9	✓	✓	✓	✓	✓
Tidiness in the workplace	8.9	✓	✓	✓	✓	■
Breaks at work	8.7	✓	✓	✓	✓	✓
Lifts	8.6	■	✓	■	✓	■
Employee morale	8.6	■	■	■	■	■
Comfortable PPE (personal protective	8.6	✓	✓	✓	✓	✓
Clear signposting	8.6	■	■	✓	■	■
Wheelchair accessibility	8.5	■	■	✓	■	■
Mental wellness	8.2	■	■	■	■	■
Manual handling aids	8.1	■	■	■	✓	■
Ramps	8.1	■	■	✓	✓	✓
Wide walkways	8.1	✓	✓	✓	✓	✓
Hand rails	8.0	■	✓	✓	✓	✓
Level access (step free access)	8.0	✓	■	✓	✓	■
Audio and visual notifications	8.0	■	■	✓	■	■
Break room	8.0	■	✓	✓	✓	■
Dropped kerbs	7.2	■	■	✓	■	✓
Hearing aid induction loops	7.1	■	■	■	■	■
Counselling	7.1	■	■	■	■	■
Colour-blind friendly signage	6.6	■	■	■	■	■
Coffee machine	6.1	■	■	■	■	■
Signage in multiple languages	5.6	■	■	■	■	■
Total score	220	79.26	105.38	145.03	138.85	95.18
		35.99%	47.84%	65.84%	63.04%	43.21%

Figure 3: An example of how a depot can be quantitatively assessed to distinguish its inclusivity (DC, 2012; Marshall, 2017; Thorkildsen, 2017b, 2017a; Chiltern Railways, 2019)

However, these are only illustrative figures; with the coronavirus outbreak, unauthorised personnel could not visit railway depots, so the results come from online research and videography of depots and should only be considered trial numbers.

This report found that staff value toilets, bright light levels, clear walkways and washing facilities over coffee and paid breaks. To achieve full working potential, staff want to change in the infrastructure, not mental health change. Adding lifts, larger car parks, and tidier workplaces are more desired than counselling or well-being to employees, which is interesting considering the multitude of well-being discussions within the industry today.

Toilets were the most desirable asset that track workers wanted as often these facilities are not provided when trackside. Staff working trackside often do so for almost 12 hours, limiting the amount they drink, so they do not need to go to the toilet. Additionally, it is often assumed that only men work trackside; therefore, toilets are not needed due to their ability to go elsewhere. The consensus from female entries in the questionnaire is that there is very little consideration for a woman's menstrual health. Often, toilets are locked, used as storage facilities, and do not provide any menstrual products or sanitary waste bins where they are needed.

Discussion

By far, the most prevalent finding for the inclusive design in railway depots was not that there was a significant issue with accessibility requirements, nor that staff felt they deserved better equipment, but simply the lack of toilet facilities in depots and trackside. Despite case study research instigating preliminary studies into accessibility and inclusivity of depots through conventional design choices, conversations with those working in railway depots inferred a less typical story. Although there may be inaccessible working environments for injured people, there are also inclusive elements missing from depot infrastructure that enable comfortable working practices.

Despite the push for more female engineers, it was discovered that women often have no toilets when trackside, no sanitary waste bins for disposal of menstrual products, and must wear clunky men's shoes and men's high visibility jackets when working. Discussions with female depot workers unearthed stories of embarrassing accidents when working, which could otherwise have been avoided by implementing adequate sanitary waste bins and toilets.

Although there is a much smaller percentage of female engineers and track workers than males, inconsistencies with sanitary waste and appropriate PPE discourage many women from working in the environment. A vicious circle, perhaps implementing or sourcing portable toilets, could solve many of the workers' concerns.

Furthermore, as societal views around cleanliness and hygiene from the coronavirus pandemic alter, railway depots will also change. Data shown in this study is not necessarily reflective of a post-pandemic world but rather a snapshot of mid-pandemic lifestyle preferences.

Perhaps most interesting from the findings was the lack of importance of 'typical' inclusive design characteristics such as multiple language signage, step-free access and audio and visual notifications. This could be partly due to the small percentage of workers who may require these additional ailments and have their vote lessened to some degree. However, for future work, it would be interesting to capture the requirements again using mobility and sensory ailment simulators to see how these considerations may change when mimicking returning from having an accident at work.

Study limitations

The work conducted for this paper was developed and carried out during the coronavirus pandemic. Abiding by the government's stay-at-home policy, all research for this paper was done remotely. In an ideal world, station depots would have been researched in person, and workshops and events held to appropriately capture a more extensive breadth of knowledge about railway depots and their workers. Furthermore, implementations could have been carried out, and a more representative study could have been performed. Due to this, the findings from this paper are merely representative and provide a possible methodology for capturing depot inclusion which could be implemented and adapted to the workers' environment changes.

Additionally, though the project was targeted at being inclusive through the study, the limitations in being able to sit face-to-face with people meant that there are likely proportions of the population that would have been unable to complete the survey and answer questions. The inability to run workshops meant that open discussions were also limited, making it harder to capture data from casual conversations with the workers.

Conclusions

Railway depots are complicated systems with various tasks and deliverables that must be undertaken to achieve goals within designated timescales. Due to the fast-paced nature of the work, it is not uncommon for staff to acquire injuries which, unlike in other practises, leave them unable to continue their job. This, combined with seemingly unclean and inaccessible working environments, leaves staff unhappy and wanting change.

With the everchanging demographic of society and the modernisation of medicine, design engineers are tasked more heavily than ever to construct pieces that suit a wide-ranging audience. Nowadays, illness and medical conditions are rarer and rarer, so anthropometric data or traditional ergonomics cannot quantify them.

Whilst inclusive design is somewhat of a novel concept in railway depots, quantifying how inclusive infrastructure is would massively reduce bias in depot analysis. This would allow for much more proficient and high-end design iterations, making design engineers focus on user-centred design studies rather than anthropometric data and previous design iterations. Quantifying inclusivity also would ensure that depots would be in keeping with the current needs of the public; with a database that could be ever-growing, the weighting factors for importance in inclusive design elements would reflect the current situation in the public eye. It would also see a prolific change in how railway infrastructure is designed, putting inclusivity at the forefront of any engineering concept rather than an iterative design added at a later stage.

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