A TOOLKIT TO MEASURE ATTRIBUTES THAT SUPPORT OR HINDER PEDESTRIAN MOVEMENT ON PEDESTRIAN CROSSINGS

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Over the past 15 years there has been a drive within the UK to rethink design to more appropriately meet the needs of a wide range of users, particularly disabled people. Additionally with changing demographics and an increasing ageing population there has been a move to broaden the concept of disabled access to that of inclusive design where design responds to the needs of the whole population. This paper reports on an EPSRC funded project which investigates the role of external environments particularly the street in supporting inclusive design. An innovative toolkit was developed to measure attributes of a pedestrian crossing which support or hinder pedestrian movement. This toolkit was complemented by on-site structured observation of pedestrian behaviour. This paper provides the overall methodological framework highlighting the ways in which the techniques were developed and used in the field, and suggests how these techniques would be modified and applied to other external environment contexts.

Keywords: external environments, inclusive design, pedestrian crossing toolkit, pedestrian movement, structured observation.

INTRODUCTION

SURFACE Inclusive Design Research Centre at the University of Salford is currently conducting an EPSRC funded collaborative research – I'DGO TOO (Inclusive Design for Getting Outdoors). Within the scope of the research, a 'Tactile Paving Toolkit' (TPT) has been developed to audit pedestrian crossings. Special emphasis has been given on inclusive design features of the pedestrian crossings for a wide range of users, particularly older and disabled pedestrians.

There are six different types of pedestrian crossings currently in use in the UK depending on the type of road, traffic volume and pedestrian demand on the road, etc.(DfT 1995a, 1995b). They are, (1) Dropped Kerb, (2) Zebra Crossing, (3) Pelican Crossing, (4) Puffin Crossing, (5) Toucan Crossing, and (6) Signalized Junction. Design guidelines applicable to pedestrian crossing design are published in Local Transport Note (LTN) 2/95 (DfT 1995a). Assessment criteria for the location of pedestrian crossings are presented in Local Transport Note (LTN) 1/95 (DfT 1995b). With the advent of Disability Discrimination Act (DDA) (1995 with 2005 amendments) various guidelines have been published for designing more inclusive

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pedestrian crossings (DfT 2007, DfT 2002, ADM 2004). With the developed TPT pedestrian crossings can be audited against these guidelines for their accessibility and related safety.

Intention of the I'DGO TOO research is to develop the TPT further to assess various aspects of the street environment related to walking (footway; bus stops; seating along a pedestrian route, etc.) in line with inclusive design principles. This paper provides a brief introduction to inclusive design within the built environment; the overall methodological framework that has contributed in developing the TPT and highlights the techniques tried and tested in the field during the audit process using TPT and conclude with suggestions that can be adapted to extend the TPT further.

INCLUSIVE DESIGN AND PEDESTRIAN CROSSINGS

The term 'Inclusive design' describes "environments that promote human functioning" (Ostroff and Preizer 2001). Newton and Ormerod (2006) defined Inclusive Design as, "A way of designing products and environments so that they are usable and appealing to everyone regardless of age, ability or circumstance by working with users to remove barriers in the social, technical, political and economic processes underpinning building and design". Adapting the principles of Inclusive design in developing environments can promote social inclusion and serve the widest range of users and customers of the built and outdoor environment. By adapting inclusive design principles a service provider can minimize liability under the DDA (1995 with 2005 amendments). Additionally the Dizabled Persons Transport Advisory Committee (DPTAC) (2003) identifies that there are social, moral, legal and commercial benefits of inclusive design that form a powerful case for adopting this approach in developing the built environment for the future. It should be noted that disability does not only refer to physical impairments but also covers cognitive or sensory impairments related to ageing or any other form of temporary impairments.

Research (Milligan *et al.* 2005) shows that mental and physical limitations are often attached to the ageing process and some older people are subject to exclusionary processes very similar to those experienced by disabled people. Hall and Imrie (1999), in their research found that older and disabled people are often marginalized and discriminated against in comparison with younger adults when it comes to designing the built environment. They also commented that until the design of the built environment takes into account the diverse needs of all users, many people will continue to be restricted or excluded from the outside world and it will affect their movement and mobility. Older pedestrians walk more to neighbourhood facilities compared to younger adults and they are also involved in more pedestrian fatalities at or near pedestrian crossings compared to younger adults (Oxley 2004). Therefore, it is very important to understand the user requirement and incorporate them within design standards and practice of road crossing points.

Research (Fujiyama 2005) suggests that the design standards applied to design of walking related facilities is flawed as they have failed to consider the phenomenon of ageing and incorporate design standards to suit older pedestrian's requirements (i.e. functional impairments). Therefore, it was the intention of this research to create an audit tool for assessing pedestrian crossings for their accessibility and inclusiveness. The tool was developed primarily based on design guidelines and good practices in the UK, Australia, and New Zealand as they are similar and comparable (LTNZ 2007a, LTNZ 2007b, SAI 2009). At the same time it proposed to validate the findings of the audit through user perspective (Older and disabled pedestrians); expert

interviews (Traffic engineers working for various local authorities in the UK); and modify the tool to suit different user access needs and local conditions accordingly.

TECHNIQUES TO ASSESS PERFORMANCE OF BUILT ENVIRONMENT

The influence of the built environment on physical activity is becoming increasingly relevant within built environment research worldwide. Various researchers have recorded the characteristics of the built environment believed to be related to physical activity by means of, (a) self reported perceptions by the local residents (Saelens *et al.* 2003); (b) audit tools used by trained raters (Boarnet *et al.* 2006, Giles-Corti *et al.* 2005, Pikora *et al.* 2002); (c) or, Geographical Information System (GIS) (Frank *et al.* 2005). Researchers have also used mixed multiple methods to investigate association between the built environment and physical activity (Millington *et al.* 2009).

Table 1: Techniques to assess performance of the built environment in relation to walkability (Abbey 2005)

Performance Design Technique	Procedure	Situation	Identifies Problems	Analyse Deficiency	Proposes Solutions	Undertaken by	Relative Cost	May Require	Example Methodology	Discussion
Reviewing	Qualitative	Existing	Yes	Yes	Yes	Professional	High	Everything below plus: safety records, traffic surveys, more observation	Good practice	Can include other tools such as auditing and/or rating
Auditing	Qualitative and Quantitative	Existing and Proosed	Yes	No	Sometimes	Technician / Advocate / Community	Medium	Everything below plus: camera, and consultation.	• LTNZ Safety Audit • Living Streets DIY Community Street Audits	Can include elements of rating
Rating	Quantitative	Existing and Proposed	Yes	No	No	Technician	Low	Mapping, site visit, incidentals such as pen paper, calculator, level, measuring tape etc	• RAMM • Cycle for Science • PERS	Attempts to infer a level of performance from a qualitative process that is transferred to a quantitative assessment

Abbey (2005) identifies three broad techniques to assess the performance of the built environment in relation to assessing walkability namely reviewing, auditing and rating although they can also be used to assess other facilities and criteria. Reviewing can be applied to existing situations and may include audit and rating as well as other assessment tools. It can be used to develop new options to improve the reviewed situation and also assess the options qualitatively for their suitability. Auditing can be applied to existing and proposed designs. It identifies deficiencies against recognized standards and can propose solutions. Auditing is ideal for identifying maintenance issues and simple remedies both qualitatively and quantitatively. Rating is a tool for

scoring an environment or facility for their intended use. It can be used on existing or proposed designs. Rating enables a practitioner to compare different existing or proposed design options quantitatively. The similarities, differences, subjective or qualitative elements of each of these techniques are shown in Table 1. Considering the three techniques, it was decided to adapt the audit technique in I'DGO TOO with some methodological modifications which are described next.

TOOLS FOR AUDITING PEDESTRIAN ENVIRONMENTS

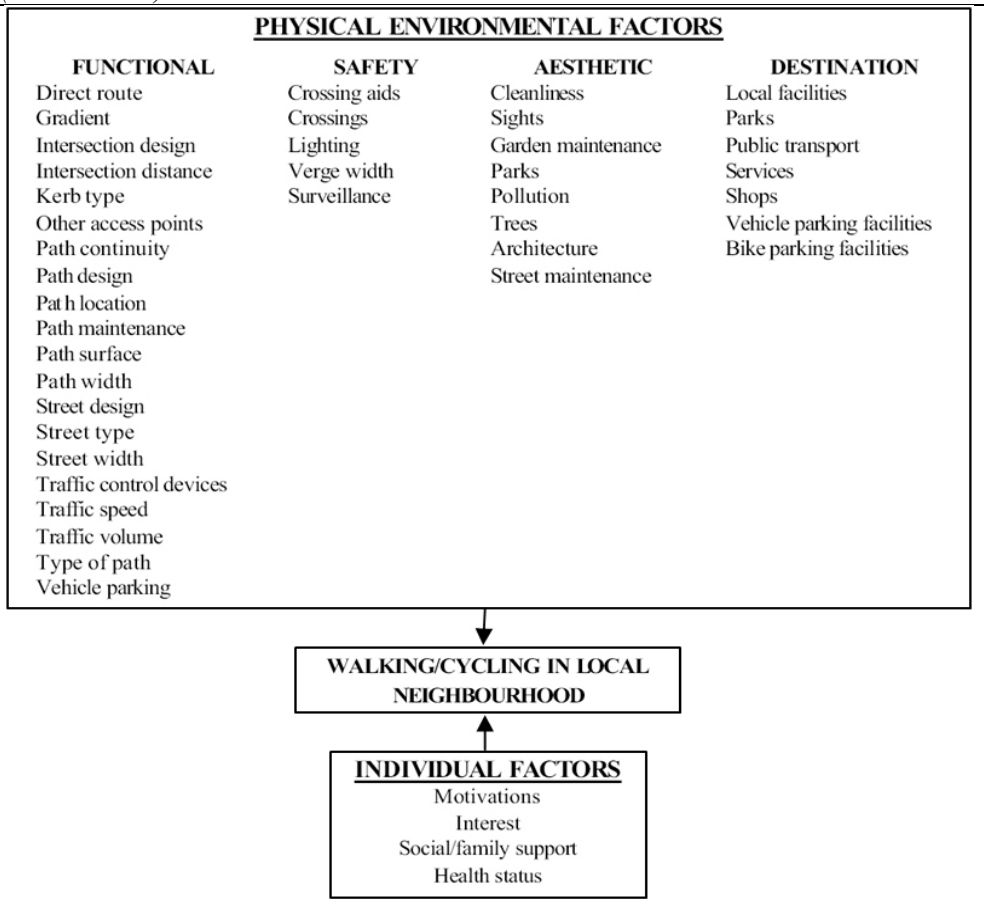
There has been a recent research trend growing around potential connections between health outcomes, quality of life, access to outdoor built and natural environment and level of physical activity including walking and cycling (Frank and Engelke 2001; Handy *et al.* 2002, Catherine *et al.* 2009). They have suggested a comprehensive and detailed environmental measure to identify the elements of the environment that support or hinder walking (Kelly *et al.* 2007). Audit tools developed to measure attributes of the physical environment related to physical activity have focused mainly on urban or suburban contexts for specific local areas. In addition, they are not flexible enough to be tailored to accommodate varying environmental characteristics relevant to physical activity based on climate, landscape, built form and cultural traditions for a new audit location (Catherine *et al.* 2009). The tools vary in target population and methods of application ((Moudon 2003; Boarnet *et al.* 2006; Brownson *et al.* 2004). A review of 31 environmental audit tools by Christine *et al.* (2007) found that 29 of the 31tools have been developed for researchers; they tend to be long and may require extensive training. Only 2 audit tools have been developed for lay persons and subjective in nature. When compared, information collected by the lay persons did not prove to be reliable (Christine *et al.* 2007). A review of the key pedestrian environment audit tools (Table 2) shows that researchers have audited the pedestrian environment from different viewpoints and research strategies. Each individual research has identified and audited different features of the pedestrian environment to inform their research. Important factors contributing to walkability, safety, user-friendliness, attractiveness, etc. of the walking environment are "still very much in contention" (Kelly *et al.* 2007) and their relationship or relative importance has not been agreed upon by researchers (Kelly *et al.* 2007, Talen 2002).

Pikora (2003) in developing a conceptual framework for assessing the environmental determinants of walking have identified the 'physical attributes' of the street and path of a local environment. According to Pikora (2003) it is not only the physical environmental factors that matters but also individual factors that affects a person's walking (Table 3). Both the review of the pedestrian environment audit tools (Christine *et al.* 2007) and conceptual framework (Pikora 2003) show that some of the environmental factors identified and audited are too general. They need to be narrowed down to assess particular aspects of each individual factor. For example, aspects related to pedestrian footway (footpath) can be footpath links, types, materials, widths, slope, etc. In addition, Christine *et al.* (2007) and Pikora's (2003) works also suggest that except for few instances the audits are qualitative in nature, and issues related to older pedestrians or accessibility has not been specifically incorporated in the tools.

Table 2: Review of 7 pedestrian environment audit tools (Christine et al. 2007)

	WSAF	WPS	SLU	SPACES	I-M	PBIC	PEPS
Characteristics							
Field protocol	√	×	√	√	√	×	√
Training presentation	×	×	N/A	×	√	×	√
Training test segments	×	×	×	×	×	×	√
PDA/tablet PC compatability	×	×	√	×	√	×	√
Tine required per segment or block	30 mn	N/A	10 mn	N/A	20 mn	5–10 mn	3–5 mn
Items measured							
Land uses							
Land uses (types, intensities, destinations)	×	√	√	√	√	√	√
Walking path/sidewalks							
Sidewalk presence	√	√	√	√	√	√	√
Sidewalk qualities (materials, obstructions, uniformity)	√	√	×	√	√	√	√
Slope	×	×	×	√	×	×	√
Natural barriers (ditch, creek)	√	×	×	×	√	×	×
Vehicle-pedestrian interactions							
Street supports for walking (crosswalks, traffic lights)	√	×	√	√	√	√	√
Traffic volume	√	×	×	×	×	√	√
Parking (on and off-street)	×	√	√	√	√	√	√
Speed limits	√	×	√	√	√	×	√
Segment/road connectivity	×	×	√	√	×	×	√
Road conditions (materials, uniformity)	√	×	×	√	√	√	√
Traffic calming (chokers, chicanes)	×	×	√	√	√	×	√
Safety and appeal							
Lighting	√	√	√	√	√	×	√
View/surveillance	×	√	×	√	√	√	×
Aesthetics (incivilities, gardening, appeal)	×	√	√	√	√	×	√
Unique markers/memorability	×	×	×	×	√	×	×
Architectural variety	×	√	×	√	×	×	√
Enclosure	×	√	×	√	×	×	√
Tree presence	×	√	×	√	√	√	√
Subjective assessmentI							
Perception of attractiveness/appeal	×	√	×	×	√	×	√
Perception of safety	×	×	×	×	√	×	√

Table 3: Physical environmental factors that may influence walking in local neighbourhood (Pikora 2003)



TACTILE PAVING TOOLKIT (TPT)

An extensive literature review on pedestrian environment (comprising UK, Australia and New Zealand guidelines) was conducted as part of I'DGO TOO. From this pedestrian crossings were identified as the walking environment feature that would be investigated from the point of inclusive design and access needs of the older and disabled pedestrians. The key features of a pedestrian crossing (depending on the crossing types) and suggested design guidelines applicable to them were identified and categorized (Table 4). Key inclusive design features of pedestrian crossings and their key installation and operational measurements were also identified.

A measurement technique was developed to measure the key elements of a pedestrian crossing, with appropriate equipment, and to record these measurements in a paper based toolkit. On the toolkit an auditor can note down the actual measurement of each component under each sub-heading of a pedestrian crossing and convert the measurements to a scale of five from 'extremely unsafe to extremely safe' in relation to his written prompts, and can also record comments, suggestions and any other observations. An example page of the toolkit is shown in Table 5.

Table 4: Identified key elements of a pedestrian crossing in brief (I'DGO TOO)

Type of crossing Road width, No of lanes, refuge island, duration of pedestrian phase, waiting time	**Refuge Island** Size, shape, dropped kerb, tactile paving, railing, second push button station
Pavement Type, width, cross fall, upstand between tiles, level space for wheel chair users etc.	**Drainage** Camber of the road, manhole grating, slope
Dropped kerbs Availability, size, slope, tactile paving	**Clearance** Street furniture to kerb edge, railing to kerb edge
Kerb edge Width, Up stand, White paint on kerb edge	**Clear un-obstructed path** Man hole/grating on crossing etc.
Tactile Paving Size, shape, height of blister, joint width, material, shape of laid TP, Stem	**Lighting condition** Measurement in Lux, glare
Colour Contrast, uniformity, colour contrasting band	**Comments**
Pedestrian push button station Location, noise signal, tactile cone, Noise level in dB	

Reliability of any audit depends on its data collection and inter-rater reliability. The measurement equipments used in this audit are very simple and easy to use. The equipments used were as follows.

- Simple measuring tape
- Distance measuring wheel
- Electron Digital Level from SMARTTOOL
- NCS Multi-colour system Hand (RM 110) Colourimeter
- Precision Gold Environment Light Meter (N09 AQ)
- Pendulum Skid tester (Mastrad S885)
- Digital Camera
- Pen, Paper, Weather protective writing board

Table 5: An example of page of the Tactile Paving Toolkit

Maintenance:

Area of Investigation / Question	Actual Measurement Near Side	Assessment Scale	Actual Measurement Far Side	Comments (If any)
107. Slipperiness	(Skid tester measurement)	19 or below = -2 (Extremely Unsafe) 20 - 39 = -1 (Unsafe) 40 - 74 = 0 75 – 89 = 1 (Safe) 90 and above = 2 (Extremely Safe)	(Skid tester measurement)	
108. Joins between tiles on footway a. Joints b. Deviation of footway surface level (within 1m straight edge) Note: Maximum deviation of the footway surface under a 1 metre straight edge should not exceed 3mm.	(Joint width in mm) (Deviation of footway surface level in mm)	a. (Note: See Q. No 27.) b. >3mm = -2 (Unsafe) 2-3mm = -1 2mm = 0 2 -1mm = 1 <1mm = 2 (Safe)	(Joint width in mm) (Deviation of footway surface level in mm)	
109. Depth of Tactile nodules		(Note: See Q. No 19.)		
110. Number / percentage of broken TP tiles (Note: No standards / guidelines were found - Consult Traffic Engineers)	Number of broken tiles/total number of tiles laid		Number of broken tiles/total number of tiles laid	

The raters with their built environment background were familiar with most of the tools. An hour's briefing was sufficient to familiarize them with the equipments. The auditors were involved in two trial audits before they went out to the actual sites. During the trial audit different measurement techniques were tried out to suit varying site conditions; actual measurements were taken and recorded in the paper based audit document; Measurements were converted to the 5 point scale. The written audit protocol was modified based on the auditor's feedbacks of the trial audits. In addition, pair of auditors was sent to the actual audit sites to assist each other in the event of confusion due to varying site conditions. This approach has proven to be very effective in increasing inter-rater reliability of the audit.

UNIQUENESS OF THE TOOLKIT

The Tactile Paving Toolkit developed is unique in many respects. An extensive literature review undertaken suggests that the concept of creating a toolkit for auditing a pedestrian environment, or part of a pedestrian environment, for its compliance with design guidelines and inclusive design principle is new. Review of the literature also shows that most audit tools did not incorporate measuring important features of the walking environment against the established design guidelines. Few audit tools, for example, PEDS, SPACES, and Irvine-Minnesota Inventory take approximate or visual measurement of the width of footways. The TPT has been used to audit 48 pedestrian crossing sites in England and Scotland between January 2008 and February 2010. In addition 3 pedestrian crossing sites have been audited in New Zealand in 2009 using the TPT to test its suitability in an international perspective. The sites vary in geographical location; topographical condition; population density; urban form; administered by 11 different local authorities and cover from most deprived areas to most affluent areas. Analysis of the entire audit data will give us an understanding of

how similar measurements with varying conditions can convey an entirely different meaning for older and disabled pedestrians in terms of inclusive design. The TPT is currently being evaluated and modified based on people's perception and difficulty that they face in accessing the pedestrian crossings. Pedestrian behaviour observation, questionnaire surveys and semi structured interviews are being conducted at each of the 48 UK and New Zealand crossings to find out people's perception and preferences about those specific crossings. In addition, local authority traffic engineers are being interviewed to understand the process of pedestrian crossing design, installation and maintenance adapted by them. Information obtained from this stage of the research will help to modify the toolkit and adapt it for local variations. Following the same principle the toolkit can be extended further to audit and analyse other elements of the walking environment; for example, Footway, Guard rails, Seating, Bus stops, etc. for their inclusiveness.

Although the toolkit is unique in many ways, there is further potential for improving it by taking advantage of the modern Geographic Information System (GIS) based technologies. Site maps and detailed drawings of each pedestrian element can be downloaded to a Personal Data Assistant (PDA). Data collected in relation to each pedestrian element can be recorded into a PDA (instead of recording on the paper based TPT) during on site observation saving the time for data input for computer analysis later. Customized software can also be developed and used in conjunction with the PDA based TPT to reduce the time required for analysing the quantitative data collected for each pedestrian environment features. Currently, the TPT includes all the six different types of pedestrian crossings with their probable variations together which make it quite long. The GIS based approach can identify the relevant sections of the TPT applicable for each study area beforehand and create a more concise version of the TPT applicable for each case study area. The case specific shorter versions of the TPT will be more user friendly and easy to follow.

CONCLUSIONS

The tactile paving toolkit has been developed to audit pedestrian crossings as part of an EPSRC funded project investigating the role of external environments in supporting inclusive design. The toolkit was primarily developed based on desktop literature survey and analysis. The audit of the UK and New Zealand pedestrian crossings using the TPT has demonstrated that the whole process was simple and easy to use. The initial audit protocol developed for the process evolved and was modified as the auditors came across varying conditions throughout the audit sites. Reliability of the data collected from the audit is high as the audit process involved taking direct measurement of each pedestrian crossing element. In addition, reliability of the collected data will be tested statistically to assess the tool's suitability of use by different auditors. Initial analysis of the data collected through the TPT audit show that pedestrian crossing design standards can often prove to be insufficient when it comes to catering for the whole population based on site conditions and personal circumstances of the user. The TPT is now being modified to suit varying context and user preferences based on expert and end user feedback. Once completed it will enable built environment professionals to audit key areas of the street environment for their inclusiveness and walkability.

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