Construction on Display: Exploring the Use of Public Displays on Construction Sites

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ABSTRACT
Construction sites are a common part of a city landscape, e.g., website Urban Toronto reports on 650+ registered works for the city of Toronto, while New London Architecture reports on 195 in London. Up until now there has been little research looking into how public displays are used at these settings. This paper reports on an exploratory study that looked into understanding the use of public displays on construction sites. By analyzing types of displays and their purpose on 38 construction sites located on 2 continents and 4 cities, I have uncovered 10 different types of displays that serve to fulfill 9 identified objectives. Based on this I provide 5 general design implications for pervasive public displays. Overall, the contribution of this paper lies in describing the use of public displays in a new context and providing design implications for them.

Author Keywords
Construction sites; urban computing

ACM Classification Keywords
H.4.3. [**Communications Applications**]: Bulletin boards; H.5.3. [**Group and Organization Interfaces**]: Theory and Models; H.5.1 Multimedia Information Systems;

INTRODUCTION
Digs for new tower blocks and high-rise buildings, canvas covering renovation works on building facades, road-blocks with wooden-fences along the street for pipeline works: these are all examples of construction sites that we can see in a city. They come in different sizes, shapes and forms, and also differ in the amount of time it takes for their completion. There are different ways for citizens to stay in touch with works happening in their city, e.g., through dedicated web pages [23], interactive maps [24, 36], or even by visiting the areas in pre-scheduled tours organized by the city officials [32]. Despite of all of this information, research has shown that in their buildup construction sites are typically perceived as deprived areas, undesirable for human interaction, and negative perception of the local community on them can even stop an entire project [26].

As construction sites are a common part of the urban landscape, e.g., there are 195 construction sites in the city of London as reported by [23], while in Toronto there are even more [36] (more than 650), they represent a potential fruitful research avenue to explore for pervasive and public displays. Therefore, I explored construction sites in order to understand this novel context and opportunities that arise in those spaces. I have analyzed what type of signage is present at 38 sites, 1 in Toronto, 22 in Zurich, 6 in Lugano, and 9 in Helsinki, and what is their purpose. The contribution of this paper is twofold:

- I explore a novel context for pervasive public displays. The findings describe ten different types of displays and their nine purposes. I also report on content organization and display dynamicity, i.e., how over time new displays emerge on construction sites.
- I present five design implications for pervasive and public displays on construction sites.

After presenting related work I describe the study design. Next I present findings from the analysis and after that I reflect on it and discuss design implications for pervasive and public displays on construction sites. Finally, I present concluding remarks.

RELATED WORK
Research on public displays has looked into different contexts, i.e., urban public spaces [20, 31], rural villages [16], third spaces such as cafes [7, 17], schools [15], working environments [22], and conferences [19]. Yet, there has been very little research that looked on construction sites as an opportunity for pervasive and public displays. Most of the current research focus around construction sites was on topics that deal with construction site/urban planning [12,38]; communication between different stakeholders [13, 26, 38] and their impact on the overall project [26, 32], as well as developing collaboration tools for them [1]; construction site dynamics [3] and on-site safety awareness [11, 21]; and personnel and objects location tracking [4, 11]. Technologies that were used in developing these systems were RFID [3], GPS [3, 4], WLAN [4], UWB [11], cloud computing [9], and displays located in work environments [1, 21].

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PerDis '15, June 10 - 12, 2015, Saarbruecken, Germany
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ACM 978-1-4503-3608-6/15/06…$15.00
DOI: http://dx.doi.org/10.1145/2757710.2757711

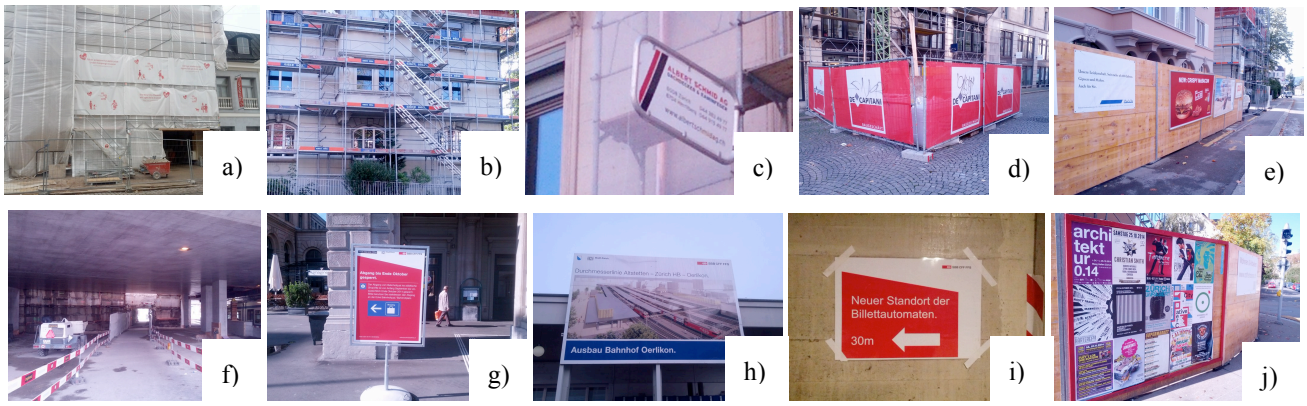

Figure 1 - Types of displays. From left to right: building façade, plank ads and posters on construction frame, ground level fence from canvas, wood, and planks, small and big poster stands, standalone poster, and public notice area.

Research that falls close to the investigation conducted in this paper is that of Merivirta et al. [21] and Hosio et al. [14]. Merivirta et al. have investigated the importance of different safety related information for construction workers. In their 4 weeks pilot deployment 2 displays were deployed in an office space located on the construction sites, in an office hall and a break room. Displays showed 25 simple power point slides, updated weekly and grouped into 10 different safety-related topics. Their survey results with 36 respondents (out of the total of 50 working on site) showed showed that updating information once a week is enough and the most important information when it comes to safety were weekly events and current matters. Overall, the introduction of an awareness display was seen as a positive addition. Complementing their work, Hosio et al. have investigated four different types of user input on public displays for the purpose of understanding people's opinion on a major renovation project in the city of Oulu. The investigated methods were on screen keyboard, simple smiley-face Likert scale, smiley Likert scale in combination with streaming messages from SMS and Twitter, and an on screen-keyboard with motivational messages that were received in the past trials. While the authors report on low number of interactions, they do report that the use of public displays had a positive impact on their major stakeholder – the Technical Center in charge of the renovation project.

Unlike the study of Merivirta et al. that looked at a specific type of information and the study of Hosio et al that focused on stimulating civic engagement and soliciting opinions about a public renovation project, the study reported in this paper is of explorative nature and analyzes types of public displays and their content, with the goal to understand current use of public displays and uncover opportunities for pervasive public displays.

STUDY DESIGN

In its nature this study is similar to previous studies that have explored practices and content around analog post boards [2, 6, 10, 35]. This study was designed as a free and explorative study, as it is first study that looked into the use of public displays at construction sites. For each visited site a researcher took as many photos as were necessary to document the look and feel of the site, as well as signage and types of displays that were present at it. As previously mentioned, total of 38 sites were chosen across 2 continents and 4 cities, 1 in Toronto, 22 in Zurich, 6 in Lugano, and 9 in Helsinki. In order to find construction sites for each city relevant online sources were used, e.g., [33, 36]. For all but 3 sites photos were taken to describe a first time user experience with it. For 3 sites in Zurich more photos were taken on the daily walk to/from work when notable changes were observed (e.g., changing advertisement or road blocks). Overall 583 photos were taken and analyzed using affinity diagram analysis [5]. A researcher wrote notes/codes that were relevant for the photos. These were then regrouped 3 times in order to come up into 11 overarching categories.

FINDINGS

In this section I describe the types of construction sites that were explored in Table 1, as well types of displays and their purpose (cf. Figure 1 and Figure 2).

Display Types

Overall there were 10 different types of displays, namely building façade, plank ads and posters on construction frames, ground level fence in the form of canvas, wood, and planks, small and big poster stands, standalone posters, public notice areas, and digital displays (cf. Figure 1). Most of the sites used ground level fence with wooden boards (19), building façade (17), and ground level fence from canvas (11) as a display (cf. Table 1). On the other hand standalone posters (3), public notice areas (3), plank ads on construction (4), and big poster stands (4) were found the least on construction sites. Interesting to note is that at two locations (Z02, H33) digital displays were noticed with changing content, however the content had no information about the works (it was mainly advertisement for the location under construction). A potential reason for a low

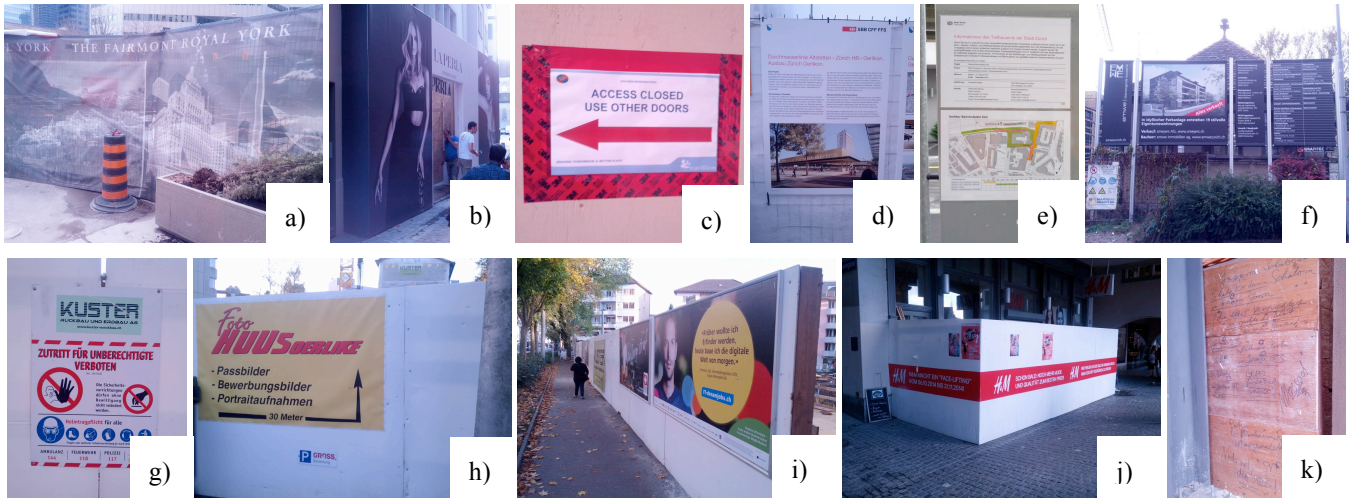

Figure 2 – Display purposes. From left to right: augmenting construction site's appearance with historical photos and store's theme and brand, temporary navigation, information about construction site and works in text and on a map, information about companies involved, notification for passers-by and workers, local and general advertisement, "guerilla advertisement" and user generated content.

number of digital displays at construction sites could be that other types of displays are easier to setup and maintain in the process.

Display Purpose

There were 9 identified purposes and types of content on them: augmenting the appearance of a site to accommodate for its current look and feel, notification for the passers-by and workers, temporary information about navigation, information about the construction site, information about the companies involved, local and global advertisement, "guerilla advertisement", and user generated content (cf. Figure 2). In the sections below these are grouped into five themes, namely augmentation, notifications, information about construction sites, advertisement, and user generated content. In addition, I report on how content on displays on construction sites is organized and compare them to previous studies on public notice areas [2]. I also describe display dynamicity on construction sites, i.e., how over time new display types emerge.

Construction Site Augmentation

Augmenting the appearance of a site was done by showing historical photos of the location (T01, H35), showing its future look (Z02, L25, Z27), using artistic images that are connected with the sites theme, e.g., an art gallery would have art displayed while a fashion store would have a models (T01, Z13, H36), or by using nicely written text, sometimes in a combination with an image (Z16, H34).

Notifications

When it comes to notifications for passers-by they were mainly different types of "do not" signs, e.g., enter, post advertisement, or park bicycles (T02, Z02, Z03, Z05, Z09, Z10, Z19, L26, Z27, H33, H37); informing that the site is under construction (T01, Z11, L24, L25, Z28, H32, H35, H39); apologizing for the site's look (T02, Z02, Z11); or were informing passers-by that this site has security or is under surveillance (Z03, Z05, H35). On the other hand notifications for the construction workers had mainly information on what they should wear and have with them when they enter the site (T01, Z03, L26, Z28). Interesting thing to note is that on one of the sites (H35) there was a letterbox installed by the construction company allowing potential communication from the passers-by to it (cf. Figure 3). Also present was information on *temporary navigation* that was typically explained with navigational arrows (T01, Z02, Z03, Z11, L25, H32) or would be simply written, while in some cases it would be explained in more details with information on exact dates when the temporary route would be in use (Z02, Z06, L24, L26, H33, H35).

Figure 3 - A letterbox installed on site H35 allowing passers-by to (potentially) drop their comments and opinions.

ID	Description	Display Type
T01	Central train station, construction indoors and outdoors, connected to a convention center.	BF, GFC, GFW, SP
Z02	Central train station, construction sites indoors and outdoors, includes underpasses.	GFC, GFW, GFP, SPS, BPS, SP, PNA
Z03	New building on the corner of the "main" street for the local neighborhood.	GFW, PAC
Z04	Renovation of a 6 stories building.	BF, PAC, PCF
Z05	Renovation of a building 4 stories building in a residential area.	GFW, PAC, PCF, PNA
Z06	Renovation of one of the entrances to the central train station.	GFC, BPS
Z07	2 adjacent street works, one is continuing into the renovation of a building's main entrance.	GFW, GFP
Z08	Renovation of a 6 stories high building in the city center.	BF, GFW, GFC
Z09	Construction site for a new building in the city center.	GFC
Z10	Renovation of a 5 stories fashion brand store in the city center	BF, GFW, GFC, 2nd floor GFC, 2nd floor GFW
Z11	Pipeline works on one side of the street going to Bahnhofstrasse	GFP, PNA, SPS
Z12	Renovation of a ground floor store in the city center.	GFW, GFC
Z13	Beginning of a construction site.	GFW
Z14	Renovation of fashion store entrance, located in multi-stories building, in the city center.	GFW
Z15	Renovation of a 4 stories building in the city center.	BF
Z16	Renovation of an H&M entrance, part of a multi-stories building, in the city center.	GFW
Z17	Renovation of a front of a 6 stories building in a city center.	BF, PCF, GFW, GFC,
Z18	Renovation of a front of a 5 stories building in a city center.	PCF
Z19	Renovation of a 6 stories building in the city center.	BF, GFW
L20	Renovation of a fashion store entrance. Ground floor of a multi-stories building.	GFW
L21	Renovation of the front of a fashion store in a multi-stories building.	GFP, GFC
L22	Renovation of a 6 stories building, with several fashion stores in it. In the city center.	BF, PCF
L23	Renovation of a restaurant.	BF, PCF, GFW
L24	Cable car station that is not working due to renovation of the major train station in the city.	SPS
L25	Renovation of multi-stories building, close to the city center.	BF, GFC
L26	Renovation of a major train station, both indoors and outdoors.	GFC, GFW, GFP, SP, BPS
Z27	Beginning of a renovation of a pub entrance. The pub is located close to site Z02.	GFC
Z28	New building in a residential area.	BPS, SPS, GFP, PAC
H29	Renovation of a 4 stories building in a residential area.	BF
H30	Renovation of a front entrance for a building, 3 stories high.	BF
H31	Reconstruction of a building.	GFM+
H32	Reconstruction of an entrance.	GFP*
H33	Renovation of a museum in the city center.	BF, SPS
H34	Renovation of an entrance to building.	GFW
H35	Renovation of a building in the city center.	BF, PCF, GFW
H36	Renovation of an arts museum.	BF, GFW
H37	Renovation of a major train station in the city center.	BF, GFW
H38	Renovation of a building close to the city center.	BF, GFP*
In brackets next to the abbreviation is the number of construction sites that had such a display. Display types: Building façade **- BF (17),** plank ads construction **- PAC (4),** poster on construction frame **- PCF (7),** ground level fence – canvas **GFC (11),** wood **GFW (19),** planks **GFP (8),** standalone poster - **SP (3),** small poster stands - **SPS (5),** big poster stands **BPS (4),** public notice areas - **PNA (3)**. These were really rare * - plastic fence, + metal fence.		

Table 1 - Construction sites description.

Information about construction sites

There were two types of *information about the construction site,* namely, textual information with the start and end dates when the works will take place (T01, Z11, H33), sometimes accompanied with a map showing the area where the works will take place (T01, Z02, Z10). In one case (Z02) there was also a poster with information on how this work connects with other works on train stations in Zurich and the area in order to improve the connection. Almost all sites had some sort of *information about the companies involved* in the construction works. However there were few exceptions (Z14, Z16, L24, H30, H32, H33). Interesting to note is that logos and advertisement of six different companies were spotted on two different locations in Zurich, and for one company in Lugano.

Advertisement

Another type of content that was found was *advertisement* that was either local promoting the place being renovated or near-by stores and shops (T01, Z02, Z03, L26, H36) or was more global promoting a brand, e.g., a globally known car brand, globally known restaurant chain, or national telecom company (Z03, Z05, Z08, Z10, Z19, L22, L23). In Zurich two different advertisement platforms were observed, Kulturplakat-Stelle (Z03, Z05, Z08, Z19) which had a structure and organization of a scaffolded display and event display [2] advertising multiple events on a single display (cf. Figure 1-j); and Clear Channel (Z03, ZZ05) that typically had a single poster frame for each advertisement, but had multiple posters next to each other (cf. Figure 1-e, Figure 2-i). Both platforms changed their content periodically and both are companies that serve to distribute traditional advertisement. However, complementing the two platforms there was also independently posted advertisement (Z05, Z10, L22, L23). On several sites (Z02, Z06, Z08, Z16, Z19, L22, L23, L24, L26, H35, H36) "guerilla advertisement" was spotted, typically advertising events or local business.

User Generated Content

Close to the above-mentioned type of content is *user generated content*. This type of content came mainly in the form of graffiti (T01, Z05, Z06, Z08, Z17, H35) and hand written scribbles and comments (T01, Z10, H35). On two sites stickers representing football clubs and magazines were found (H32, H35).

Content organization and display dynamicity

When it comes to content organization and its appearance it can be compared to previous studies on public notice areas [2]. While the majority of content was closer to unscaffolded displays as there was no clear structure of how the content was arranged (cf. Figure 1-a, -e and Figure 2-i), two sites (L22, L23) formed a row on construction frame for advertisement (cf. Figure 4). This is much closer to scaffolded displays that have an arranged structure for ad placement. Also, observed PNAs were typically event displays [2] and also information displays [2] with a focus on events happening in the locality and providing information about the construction site works and companies involved respectfully.

As mentioned previously, content on some of the displays is dynamic and gets updated. Similar thing can be said about displays present at a construction site: the more it progresses the more types of displays it gets. In Figure 5 we can see an example of such a change, i.e., in the left image we can see wooden ground level fence that was initially present, and in the right we can also see it as well as plank ads on the construction, which were added after some time and as the site progressed.

Figure 4 - An example of scaffolded poster arrangement on construction frame (PCF)

Figure 5 – Display dynamicity of construction site: As a construction site progresses new types of displays show up.

REFLECTION AND IMPLICATIONS

I reflect here on the study and findings and provide design implications for pervasive public displays. Overall, we can say that construction sites have different types of public displays present that serve different purposes, or in other words *construction sites are a display of public displays*. On construction sites we can find public displays of different shape and size, e.g., a whole building façade and ground level fence (cf. Figure 5) as well as standalone posters and smaller printed signage (cf. Figure 2-d and Figure 2-c) or can be even "sticking out" of the site (cf. Figure 1-c). Their assembly is not static, i.e., as a construction site progresses more types of displays can show up. When it comes to pervasive public displays design implication here would be that researchers and developers working on public displays for construction sites should be informed about the site's progress, as it (can) give more opportunities for different sizes of a display. However, also combining them into a single experience can be an interesting opportunity. Understanding the influence of display placement in space [8] and display configuration [18] would help.

Also, *construction sites are a showcase "display" for the companies involved in it.* Companies mark their site as

theirs either through a nice poster on a building façade or construction frame, or through a simple writing on a ground level fence. When a larger number of companies are involved they are even willing to put up a separate billboard to list all the companies, e.g., as shown in Figure 2-f. As mentioned previously, companies have multiple sites in a city, which makes their "marking" even more significant, e.g., to show their importance in the region. As shown by previous work, public displays on construction sites make for "accountability technology" [25], i.e., they (can) allow the general public to see if the works are conducted on time, what is the budget, or can even allow for tying the companies with political parties. A design implication here would be to make sure that content on pervasive public displays reflects companies involved in the building, as construction sites serve as a "beacon" for them, signaling their work. Potentially, these displays could form a network across different sites where companies conduct their work.

Content about the construction site is driven by practical needs, e.g., navigation, information on when the works will start/end, and companies and partners involved. Some sites had public notice areas and other form of displays put up specifically for this purpose, in order to inform passers-by on what happens when and how that affects their route. As noted in two locations (Z01, L24) this practical information can even go that far to explain the importance of the works carried out in connection to other works that are carried out in near-by locations, i.e., connecting other sites that are affected by the work. Interesting to note also is that when it comes to navigation a large portion of displays were a simple arrow with destination name and distance. Also, some local businesses that were affected by the site had navigational information that also served as an advertisement. A design implication here would be that content on pervasive public displays should have up to date information on the works carried out, specifically paying attention to navigation. However, it would be important also to understand if a particular site has a bigger significance that goes beyond its locality and connects with other works – this should also then be reflected through the content. One thing to note is that while there is a need for bigger public displays, construction sites also have a need for smaller forms of self-powered displays that show very simple navigational content [28, 37].

Construction sites present *an emerging opportunity for both advertisement and user generated content.* As previously mentioned, this allows existing advertisement companies (e.g., in the case of this research those were Kulturplakat-Stelle and Clear Channel) to take advantage and advertise, or even to allow independent advertisement in compliance with the construction companies and site owners. Also, one thing to note is that advertisement for local businesses that were affected by the site seems like a must. When it comes to user generated content, it comes in different forms, i.e., graffiti, handwritten messages, and small stickers. A design implication here for pervasive public displays would be to provide balanced opportunity for both types of content. When it comes to advertisement, it would be highly advised to provide different types of content arrangement, e.g., a grid layout, closer to scaffolded display, and full screen. However, there might be also different types of content arrangement depending on cultural preferences. Also, these layouts could be combined if there is a limited number of displays that can be put up. When it comes to user generated content very simple applications would support it, e.g., painting/graffiti [30] and scribbling [7], pins/stickers [17], or even more advanced like situated snapshots [20]. An interesting opportunity lies in allowing passers-by to communicate with the site and companies involved (cf. Figure 3), and pervasive public displays could support them in such actions [31]. One thing to note is that supporting user-generated content can potentially lead to "astroturfing", i.e., masking the companies involved and problems with the site. For example, a colorful construction site wall or a display with paintings from schoolchildren can create an impression of broad community engagement and acceptance for a project that might be actually controversial for the local community.

Lastly, construction sites represent an *emerging opportunity for augmenting the site and creating more pleasant user experience*. Some of the motivation for this comes from actual augmentation of the site's look with historical or futuristic photos of the location or with artistic imagery that connects with the site's theme. However, this can also be connected with signage apologizing for the site's current look, signifying that a more pleasant look would be appreciated. Also, one thing that could help passers-by to adjust their expectations before entering an area under construction could be the use of pre-emptive signals and displays, as was observed at some sites. A design implication here would be to understand the site's priority, i.e., is it history, future, or site's work and business that should be promoted, or even the combination of the three. Also, creating a more pleasant user experience can be connected to supporting user-generated content and allowing people to express themselves.

CONCLUSION-

Although public displays have been used in many different contexts, e.g., urban public spaces [20, 31], rural villages [16], and third spaces, such as cafes [7, 17], no research has tried to understand what type of displays are placed at construction sites and what information they carry. By analyzing signage present at 38 sites located in 4 cities spread across 2 continents, existing types of public displays and their purpose was presented, as well as design guidelines for pervasive displays to be used in this context.

ACKNOWLEDGMENTS

I would like to thank Hele Ai He, Christian Remy, and Gunnar Harboe from the ZPAC Lab for their feedback on an early version of this paper.

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