Parametric bus stop shelters in rural areas

Automating custom design

Jaroslav Hulin¹, Jiri Pavlicek², Martin Kaftan³
¹,²,³Czech Technical University in Prague, Czech Republic
¹http://www.echorost.com
¹jaroslav.hulin@echorost.com, ²jiri.pavlicek@echorost.com, ³martin.kaftan@echorost.com

Abstract. This paper describes the first stage of an applied research project that explores parametric design strategies in a context of rural bus stop shelters. The aim of the research is to propose a possible method for improving current state of public infrastructure in rural locations of the Czech Republic. The research project examines, in a practical way, how advanced design techniques and new technologies could help architects and designers participate in some areas of the building industry that have been out of reach of professional designers. Rural bus stop shelters in Czech Republic serve as an example of one particular ‘unreachable’ area. During the first stage of the research (described in this paper), we developed a parametric system of design and production of a bus stop shelter and we commissioned a fully functional prototype to be built. In the outlook of the research, participation of users in the design process is outlined.

Keywords. Parametric design; mass customization; participatory design; bus stop shelters.

INTRODUCTION

A bus stop shelter, too small to be a proper building and too localized to be a standard object, usually stays out of interest of architects and designers. Still, many are designed (not necessarily by a professional) for a specific location.

In cities and dense urban areas bus stop shelters are well maintained since they yield a considerable profit from advertising placed on them. In a city, bus stops are built and managed by one company; they are prefabricated, identical, with minor variations allowed by modular assembly system. There is no need for great design differentiation, and in some cases a common design can help people orient in a busy environment. In cities, bus stop shelters can be easily recognized and thanks to standardization their construction and maintenance costs are reduced.

In rural areas, there is usually only one shelter in a village. The shelters have a considerably unique appearance and can differ in shape, material, construction system, number of walls, openings, quality of detail or cost. Individuality and ad hoc solutions have always played an important role in rural life and culture. Even a strong tendency of prefabrication and mass production during the communist era of Czechoslovakia did not set a trend of prefab shelters in Czech or Slovak villages. This huge demand for individuality on one hand, and the marginality of the topic from architects’, builders’ and manufacturers’ point of view on the other hand, have led to a whole range of strange, surprising, weird and funny solutions.
PROBLEM DEFINITION – RESEARCH BRIEF
There can be several reasons for which village bus stop shelters are not designed professionally. It is not the aim of this research to define them all. We focused on solutions for the two most obvious ones; (1) high cost of professional designer work (compared to an average village budget and cost of local labor) deter councils to assign the commission to a professional and (2) a demand for individual solutions excludes professionally designed and mass produced city-style shelters.

The experiment tests two hypotheses:
1. If we could automate or eliminate the post-conceptual architectural work (design development, technical design, production information, tender documentation or on site supervision) the overall unique shelter price would be already close to that designed by non-professionals for free. A standard architects’ fee for a bus stop shelter can easily double its cost. However preparation and conceptual work usually make less than 10% of the whole fee for a standard building.
2. If we could use some of the advantages of mass production, e.g. automation, quantity rebates or trained yet inexpensive labor, and still produce unique enough shelters, their price could compete with the ones mass produced.

The described project takes advantages of methods of mass customization. (More in Kolarevic, 2003) Early theoretical experiments in architecture, carried out for example by Oosterhuis(1999), Duarte (2000), Larson(2001) or Matcha(2009) were focused on parametric generation of single family houses. All the experiments supposed more or less independent parametric system driven by a non-professional user, customer. Users were asked to express their preferences intuitively or to make informed and conscious decisions (about number of rooms, their sizes, material or features). As a result of such a system, design documentation was supposed to be produced automatically and many times, CAM manufacturing techniques were suggested for facilitating differentiation. Such proposals outlined a useful framework which serves as a reference in our experiment.

Several practical examples of mass customization can be found in fashion industry, such as already famous Nike's ID where you can mix and match color of your shoe parts, Freitag's F-Cut online tool in which you can mark particular pieces of a former truck tarpaulin from which your messenger bag will be made. [1], [2] Both of these examples represent an upgrade of the companies' standard service and as such the custom made products are considerably more expensive. An interesting example of custom co-designed products is represented by an online company Fluid Forms which focuses on production of smaller objects and jewelry. [3] The objects are designed by a professional with some degree of user

Figure 1
Examples of variability of bus stop shelters in the Czech Republic.

486 | eCAADe 29 - Generative and Parametric Design
participation already in mind. You can for example ‘design’ a pattern on your clock by picking a location and a scale on Earth’s map.

**PARAMETRIC DESIGN – METHODOLOGY**

As practicing architects we approached the brief intuitively. First, we designed a single shelter for a specific site and for a specific client. The concept was inspired by a traditional village chapel and the floor plan allowed for various arrangement of waiting people. The general appearance of the shelter refers to both the concept and material limitations, such as structural capacity or maximum dimensions of sheet metal. The structural concept is based on folded edges of each of the cut metal sheets. Folding angles are different for each edge. Individual pieces were folded together manually. Neither scaffolding nor special technology was needed during the assembly process.

The original shelter was already designed to take advantage of mass customization including parametric modeling, user participation and digital fabrication. In the next step, we designed several other versions of the same concept for different site and client conditions in the same way. From that we were able to generalize (or almost reverse engineer) four rules that helped us define a framework of our variable design family.

- **Shape variation needs to be rather substantial.** Layout should allow for various modes of waiting (individuals, strangers, neighbors, friends, children…). The overall shape will have to reflect rather different contextual conditions.
- **The design family should have a single topology** in order to automate production of shop drawings. Multiple topologies would render such a small project too complicated. Seemingly topologically different variations are facilitated by post-rationalization. Vertices are merged into a single one when they get too close to each other.
- **Limit size of individual structural members to the maximum standard size available off shelf** (for sheet metal in Czech Republic it is 1.5 x 3.0 m). Bigger sizes would increase material and fabrication cost. A small change in shape can have a significant impact on cost. Split larger faces in order to simplify production.
- **Try to minimize waste.** Freeform shapes cut off a standard rectangular sheet leave behind a lot of waste. Economy of production is compromised by design. In our case, triangles of a pitched roof do not always fit onto a standard rectangular shape of metal sheets. We should try to save money by careful nesting and final pre-production adjustments.

In this stage of the project, a fully independent parametric design system proved to be unnecessary. The most important parameters, that had a major influence on the overall appearance of a shelter, were usually the least specifiable ones, e.g. historical context, cultural preferences or general character of the given village and its landscape. Early practical tests showed...
it was easily manageable to process these inputs intuitively and devise a shape which would reflect specific conditions. Such a traditional approach allowed us to adjust and process various parameters including their weights according to our intuition and experience.

A parametric model and design tools were used during later design stages. Thanks to custom built scripts in Rhino3D, we managed to automate most of the time consuming tasks, such as cost and manufacturability analyses or production of documentation, in a relatively short time. By our estimation, we saved about 80% of the design time by automating 20% of the tasks. However, due to the custom built tools, the overall development time of the first prototype was almost twice as long. The “investment” starts to pay off with the third shelter.

Our parametric model starts with a single, yet complex parameter – shape of a shelter. The computer runs analysis in real time. We could either change the input shape and test it again or leave it and generate raw shop drawings. With several custom made software tools, such as unfolding or labeling script, a complete set of shop drawings and details could be produced and checked within half a day of work. It would require further development to fully automate the task, which would be worth doing only from a certain number of shelters produced regularly.

**PROTOTYPE**

Cost of skilled labour in Czech Republic is still below the cost of modern CNC machines. The whole fabrication process was devised to be compatible with both hand and CNC manufacturing. The prototype was built with a manually operated machine that cut and folded weatherproof metal sheets. It could be produced locally for a standard price. The material was selected for its universality which allows for different options to be built in the same exact manner. Thanks to the thickness of only two millimetres, it was possible to generate cutting patterns directly from a simple 3D model without adjustment for material thickness and physical imperfections. The material allows for prefabrication, easy transportation and maintenance. The prototype was produced and assembled in two weeks time. The final treatment of the metal sheets could be another parameter.

*Figure 3*  
Variations of a single design family.
OUTLOOK
A semi-automatic design tool described in this paper can offer designers new opportunities in marginalized areas of building industry. Yet, any commission starts and ends with a client. The next step in our research is to test whether and how clients and users can participate in the design process. The result of participatory design process is generally received better by local inhabitants. Contextual parameters defined during the participatory design process can serve as an input for a fully automatic, generative design tool. Being locked in predefined boundaries of possible solutions, an outcome of the participatory design process is supposed to be relevant, buildable, partly design by us and partly co-designed by the users.

At this time there exist more than twenty basic versions which differ in size, cost, utility parameters defined during the participatory design process can serve as an input for a fully automatic, generative design tool. Being locked in predefined boundaries of possible solutions, an outcome of the participatory design process is supposed to be relevant, buildable, partly design by us and partly co-designed by the users.
function, safety or liability to vandalism. These qualities and features are well described on every version’s data sheet. The range of versions is not closed as we expect to improve the basic set over time. For every different site, the basic options can be pre-selected using both subjective and objective criteria, such as load bearing capacity (in some regions, there could be more than 1m of snow during winter months), cost or orientation to the Sun and wind. The pre-selected group can help to start a participatory design session. All the options are topologically identical and so it is would be rather simple to algorithmically generate new variations. Thanks to the parametric model and CAM methods, design and production of such variable bus stops could be sped up and carried out within standard budgets.

**CONCLUSION**

The aim of the project was to practically test a semi-automatic experimental strategy that could improve current state of rural bus stop shelter “design” and could inspire solution of similar problems – for example, only a small proportion of family houses are individually designed by a professional architect or a designer. It turned out a fully automatic generative design system was impractical since its limitations and complexity would outweigh its benefits. For our practical experiment we managed to automate most of the post-conceptual work. With such a tool, a designer could be much more productive. The cost of such a custom designed shelter would be comparable to a shelter not designed at all.

For the second part of the experiment, a fully automatic design is suggested. The experiment should test various ways of user participation in design of mass customized, user co-designed architectural objects.

**ACKNOWLEDGEMENTS**

This research was funded by the Czech Ministry of Culture.

**REFERENCES**


