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LOCAL OPTIONEERING

Producing complex geometries through opportunistic networking

FINNIAN WARNOCK AND STANISLAV ROUDAVSKI
The University of Melbourne, Australia
f.warnock@student.unimelb.edu.au

Abstract. How can small architectural practices participate in contemporary architectural experimentation? One route is through engagement with complex, parametrically controlled geometries. However, the utilisation of such geometries by small practices is comparatively rare. We sought to explore the circumstances of such engagements with the hope of finding what can make them more feasible. To this end, we developed a purpose-specific methodology based on the simulation of an integrated design workflow. To develop and assess this simulation, we exposed a hypothetical project to multiple stakeholders including fabricators, engineers, architects, builders, clients, planning authorities and researchers. The outcomes suggest that the conceptual stance described as optioneering in application to large projects can also be productive at smaller scales.

Keywords. Digital architectural design; digital fabrication; local expertise; parametric geometry; design innovation; optioneering.

1. Introduction: elitist complexity

Experimentation with complex, curvilinear geometries is prominent in the contemporary architectural thinking. Their development, utilisation and questionable desirability belong to a broad theme that is well beyond the confines of this paper. Instead, we consider what frames the implementation of such geometries when the aspiration to use them is already present.

An increasingly common method of producing complex forms is through parametric geometry. Parametric design techniques are said to offer flexibility, speed of exploration, means to process large amounts of data and the ability to fabricate directly from computational models.

Recently, a number of high-profile and geometrically complex projects were completed in Melbourne. These include Federation Square by Lab Architecture Studio, Rectangular Stadium by Cox Architects and Southern Cross Station by Grimshaw Architects. More are on the way, e.g., cf. The Swanston Academic Building by Lyons Architects, due for completion in 2013. Exploration of complex geometries in these projects indicates sustained local interest in their possible applications. This local interest, combined with other regional characteristics (cf. economic and cultural contexts, population size and density, available institutions, etc.), frames and limits our findings.

Kieran and Timberlake (2004, p. 11) argue that fabrication (and not construction) can overcome the linear dependence of quality and scope on cost and time, allowing the art to transcend resources. They also suggest that as a result of the slow uptake of fabrication within the construction industry, current practices have become outdated, inefficient and technically limited (Kieran and Timberlake 2004, Woudhuysen and Abley 2004). We observe that this lack to technical aptitude – especially at the local level – has led to a widespread assumption that the production of complex geometries is unattainable by all but the well-financed international elite, working on very large projects. Unfortunately, small practices frequently fail to test this assumption and accept that complex geometries are beyond them.

To illustrate, the aforementioned projects were produced by medium (11 to 30 employees) or large (more than 30 employees) firms (these size definitions were informally advised by the Australian Institute of Architects). While exceptions exist (in Melbourne, cf. McBride Charles Ryan, Harrison White Architects and HATZ Architects), our survey of the local field indicated that small (less than 11 employees) practices are rarely involved in geometrically advanced, computationally sustained projects.

The initial interest in the research presented in this paper was provoked by this observation. Our literature survey demonstrated that – currently – there is little written material on factors influencing the production of complex geometries by small practices. Consequently, there is little guidance on how to cope with limitations. These limitations extend well beyond purely technical. We are aware that architectural experimentation is typically produced for powerful or affluent clients and that local builders typically have little interest in or means for innovation. While the overarching motivation of our work is to contribute to the change in this culture, the general discussion of these themes is beyond the scope of this paper. Instead, we hope that this report on our research-in-practice can serve to indicate the directions for further study and provoke useful discussion.

2. Research method: simulated design development

To explore our research field, we organised a hypothetical project (called *Ripple*), which proposed a complex facade of articulated ribbons. We chose the ribbon as a geometric system because it provided a rich test case. With no local project with a similar approach, a custom production process had to be investigated and designed. This process considered finances, procurement patters, available expertise, design technologies, construction methods, material choice, structural systems, stakeholder jurisdiction and so on. To reveal the relevant factors, we organised a series of consultations with a broad range of stakeholders including fabricators, engineers, architects, builders, clients, planning authorities and researchers. During the initial search (that simulated an approach available to a typical small practice), we contacted potential contributors because we knew of their past involvement in relevant projects or estimated that their expertise could be repurposed to the project's goals. Their names were sourced through publicly available project credits or through personal recommendations by local peers. In accordance with the typical small-firm work practices, all contributors were local. By confining the project to the local setting we gained direct access to the stakeholders and could utilise our knowledge of the local context. On the other hand, the decision not to extend the search internationally constrained the palette of expertise and technologies. In the future, it would be interesting to show how small local practices can engage with international experts, for example through online communities.

To develop an informed, inclusive understanding of the factors at play, our consultations with local experts were integrated into the iterative development of the project. During these consultations, contributors were asked to comment on specific aspects of the design, drawing from their areas of expertise. The hypothetical, non-commercial nature of the project meant that its development differed from those of real projects in a number of aspects. For example, issues such as internal program, floor areas and servicing were not considered in great detail during these meetings. The project did not go through a realistic procurement process and so on. However, the project's theme was verified with local architects who confirmed it as parallel to their past work. In consultations, all experts were asked to consider the project as a real practical challenge. Consequently, the conversations replicated those possible (or typical) during normal research and development. The consultants frequently used real (past, ongoing or future) projects to source examples or evidence. The ensuing discussions could highlight relevant issues, test assumptions and generate new ideas. After each consultation (or a series of meetings), the design was rearranged according to the stakeholder's advice and then revealed to the next expert. Figure 1 shows six key stages in this development process.

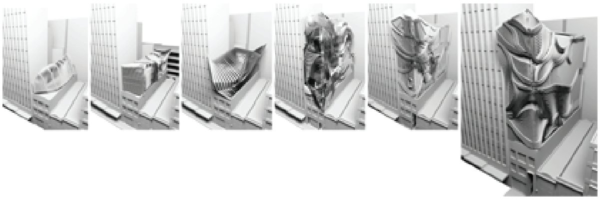

Figure 1. Key stages in the development of the Ripple project.

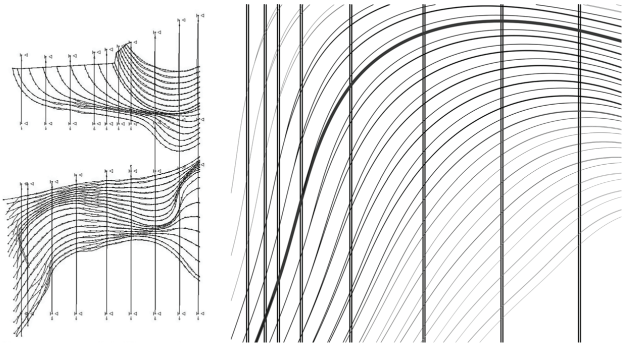

Figure 2. Left: evaluation of deflection and generation of vertical distributions in Space Gass. Right: bunching of vertical support members. The horizontal offset between vertical support members can be varied so as to keep ribbon-segment lengths similar.

An example of the interaction that informed this development can be seen through communications with Jon Anderson, a structural engineer with a special interest in parametric design. The consultation with this expert focused on resolving the vertical elements supporting the ribbons. Anderson's Grasshopper to Space Gass plug-in (Figure 2, left) allowed a variety of steel profiles to be applied to the vertical members in order to establish the minimum thicknesses necessary to satisfy vertical and horizontal deflection. It also revealed that the vertical structure could be optimised by bunching the support members in relationship to the angle of the ribbons (Figure 3, right). This association could then be automated in the parametric model before the project was shown to the next stakeholder.

Key stakeholders saw the project multiple times and were able to see how their suggestions and the input of others affected the development. It was particularly beneficial to conduct these consultations in the work places of contributors – flexible access to the tools and technologies available there frequently led to spontaneous ideas and supported innovation. For example, such benefits were obvious when working with Rock Martin, specialist metal fabricators. In the discussion on how to fabricate an undulating metal ribbon economically, they were able to demonstrate how a jig built for a previous project could be modified to produce an incremental curve over a laser-cut metal profile. The tangible understanding of the mechanical process gained through this encounter expanded the design space and led to new design decisions.

To conclude, the adopted methodology proved effective as a research tool. Multiple experts became involved in the project, to which they contributed with enthusiasm and without remuneration. On the basis of this experience, our impression is that a similar process could be adapted to serve as a research phase in a real project. We intend to test this speculation in subsequent work.

3. Limiting factors

The feedback gathered through our consultations was specific to the project. However, some of our observations can be applied to generic situations operating under similar constraints, not as normative recommendations but as suggestions for exploration. We realise that deeper and/or broader research would reveal a broader range of limiting factors, beyond those directly encountered in our project. These factors might include socio-economic limitations, cultural and aesthetic concerns, the risks of narrow specialisation for small practices, the reasons behind firm sizes, legal regulations controlling professional responsibility and the need to justify experimentation in a competitive market place.

The limited range of factors emanating from our research is presented in three categories. While these categories have emerged from the consultations, they are a narrative convenience rather than an ontology and should be understood as such.

3.1. EDUCATION

Educational factors relate to the slow rate of professional development in the construction industry. Adrian Stanic, director at Lyons Architect, a medium-sized firm engaged with the contemporary digital discourse and Jon Anderson (HIVE Engineering) both commented that a prevailing inability to keep up with conceptual and technical developments is detrimental to architectural, engineering and building professions. Stanic commented that even progressive architecture firms such as Lyons Architects tend to rely on the skills brought in by recent (read inexperienced) graduates as a means of staying in touch with developments in architectural computing. Smaller firms typically do not have the resources needed to explore new or experimental processes. Anderson commented that the only other engineering firm that he knew to have a thorough understanding of parametric software, in Melbourne, was Arup.

There are certain benefits that come with using older and more labor intensive CAD programs, state fabricators from Rock Martin. Such software (e.g., AutoCAD) requires more user input and can focus the designers' attention on how individual elements will be fabricated and joined. The laborious CAD drafting then acts as a virtual check list. However, manual drafting also limits the possible complexity. A possible response to this situation, given the limited resources, is partial and targeted implementation of parametric models for the key components of projects.

Ross Berryman, a builder with more than 20 years' experience, commented that builders and other consultants are often struggle to read 2D architectural drawings. Mistakes regularly occur due to misinterpretations, the risk of which is compounded as the project becomes more complex. Berryman advocated the use of 4D visualisation to convey assembly and construction processes and to detect potential problem/collisions, for instance spanner swing radiuses (small scale) or crane fixing points and panel tessellation/stacking (large scale). A parametric model can supply such representations rapidly and conveniently. For example, a similar process was used successfully by Drew Williamson, the project architect from McBride Charles Ryan. When a slight change occurred on site during the construction of their Klein Bottle House, Drew updated his 3D model and then supplied screenshots directly to the builder on which he annotated the corrected cut angles and member lengths.

To conclude, building and maintaining expertise is a major challenge for small architectural practices. How can digital-tool builders, educators or practice communities address this need? We are not ready to answer this question but suggest that this issue requires the attention of the research community. For example, it would be interesting to explore whether strategies that are now emerging in large scale projects can be applied at the local level. Can open-source knowledge-sharing contribute to the development of local expertise? What can reward such broader sharing in the context of patentable technologies and for-fee advice? Can small local practices import external expertise through optioneering and team building as it is implicated by "integrated project delivery" or "multidisciplinary design optimisation" approaches? As Carpo (2011, p. 162) observes, some large offices have recently started to offer comprehensive BIM packages for smaller architectural firms, including software, consulting, and possibly full project delivery. Such initiatives raise further questions on the balance between pre-packaged commercial tools and more flexible aspirations of computational creativity. Do small practices have to buy all of the necessary expertise? Can they extend their explorations by attracting students and recent graduates? How can universities and professional bodies support them in this process? In our research, the broad and ongoing need for education well beyond the university's environments emerged as a unique contemporary challenge that requires further focused attention.

3.2. COMMUNICATION

Factors of communication refer to the transfer of expertise and information between stakeholders. They include difficulties in transferring geometric information between software packages, while maintaining parametric capabilities. Stanic (Lyons Architects) has found an inability to stage such a process often produces a situation where a particular stakeholder begins using parametric software but finds that the benefits are limited because they cannot efficiently communicate with other parties. For example if Lyons Architects were to build a detailed parametric model using Revit and then pass it on to a services engineer who was unable to add ducting to the model, the potential for detecting collisions becomes unavailable, undermining the usefulness of the model.

Within Melbourne, small practices have accumulated methods that begin to address this issue. For example, Jon Anderson (HIVE Engineering) developed plug-ins that allow automated transfer of large quantities of geometrically complex information from Grasshopper, Rhinoceros 3D and ArchiCAD (examples of design software) to Space Gass (engineering evaluation software). His system could support the rapid, accurate structural evaluation and optimisation of *Ripple's* ribbons and vertical members. Marcus White, a partner at Harrison White Architecture, has taken a different approach wherein he uses the capabilities of 3DS Max, in conjunction with a number of plug-ins, to test a variety of factors that would otherwise be in the domain of a specialist consultant. He keeps a project in 3DS Max for as long as possible, maintaining maximum flexibility, before moving the project into documentation software.

As was already mentioned in the discussion on methodology, the physical proximity of stakeholders can be advantageous because it allows collaborative sketching of ideas supported by tangible interactions with prototypes, materials and fabrication processes. For instance when working with Rock Martin, ideas for the potential fabrication of a triangular-profile ribbon were quickly sketched and developed (Figure 3) through face-to-face interaction where designers was able to direct fabricators' expertise to support their design intent. Their conversation resulted in a deeper shared understanding of project goals and technical limitations.

According to Stanic (Lyons Architects), another issue that arises when dealing with experimental projects is who takes responsibility for the complications that are likely to occur and who pays for them to be remedied? This mentality is encouraged by the segregation of the building industry and the separation of legal responsibilities. Stanic proposes that collective practices or alliances, where members (architects builders and clients) enter into an agreement in which liability is equally shared, can offer a solution which could potentially allow for greater experimentation.

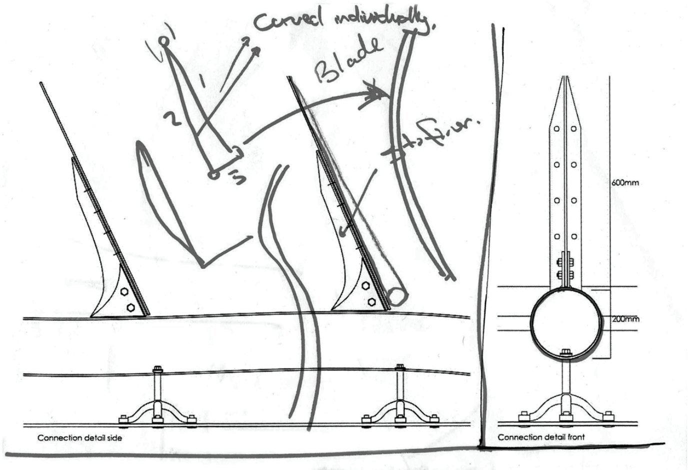

Figure 3. Sketching of ribbon options.

To conclude, our observations demonstrate that small practices tend to rely on face-to-face communication and local support networks. Consequently, it is reasonable to speculate that further integration of architectural computation into their workflows will need to cohere with these working practices. For example, both Marcus White (Harrison White Architecture) and fabricators at Melbourne Laser Cutting stressed the need to understand how information could be most conveniently transferred and presented to different stakeholders. As Di Maria and Micelli (2008, p. 275) observe, "literature on local manufacturing systems and industrial districts has given little attention to the ways cognitive processes are organised and take place within local contexts." Hence, future work could focus on flexible communication protocols that integrate physical and digital communication with the aim of supporting rapid evaluation of multiple options, again in parallel with the similar ambitions that are currently being explored at larger scales (e.g., cf. Holzer 2006, 2009).

3.4. PROCUREMENT

Stanic (Lyons Architects) and Anderson (HIVE Engineering) have both found that clients are often wary of the risks associated with an experimental project and choose to pursue more standard approaches as a result. Furthermore, Anderson (HIVE Engineering) and Drew Williamson (McBride Charles Ryan) agreed that one of the primary factors limiting broader utilisation of complex geometries is the difficulty in assessing the additional costs. Anderson believes that when BIM will allow architects to state that, for instance, a ribboned façade will cost 15% more than a typical glass curtain wall, clients will be more likely to accept more complex proposals. Williamson (2011, p. 411–413) adds that through the use of digital 3D models, costs can be essentially parametricised but expresses concern for the "considerable limitations" to innovative design caused by the predefined-family paradigm used in most BIM applications. The restricting factor is not whether a particular system is buildable. Instead, it is in the relationship between extra cost and demonstrable additional benefits. In these cases the reasons – such as building performance or cultural considerations – must extend beyond the obvious geometric novelty.

Marcus White (Harrison White Architecture) comments that budgets that do not allow for research and development costs can lead to stagnation in architectural experimentation. In response to this Anderson (HIVE Engineering) suggest that small, specialist practices with highly focused interests are able to offer cutting edge expertise at lower prices than larger firms, as they do not have the high overheads that the larger firms carry. This statement promises an interesting alternative because it is unlikely that small practices will ever be capable of sustaining the broad expertise necessary for the production of all types of complex geometry (even without considering the much broader spectrum of other technological opportunities). However, this approach requires an adequately rich local industry able to supply such specialists as well as a developed local community able to connect such specialist into task-specific teams. An engagement with this field can then be – again – interpreted as optioneering; or an opportunistic methodology that takes advantage of the available expertise and allows these constraints to inform design directions.

4. Conclusion: towards local optioneering

This paper began with the conceptualisation of the "local" as an imposed characteristic that comes with limitations. These limitations are certainly real. However, our research demonstrated that local conditions also have pragmatic advantages and should not be automatically interpreted as constricting, merely as different. The exact nature (or rather – productive interpretations) of this difference has to be the focus of future research work. This line of thought can be further reinforced with the ideas emanating from the overarching discourse, for example on sustainability and creative communities where the role of global-local manufacturing is being actively discussed. In particular, directions of future research, suggested by our work to date, might include a comparative study of a broader variety of local contexts and a broader survey of local capabilities extending beyond personal impressions of individual experts.

The aim of this paper was to show that – according to our limited observations – the very challenge of local production of complexity requires engagement in contemporary architectural discourse and experimentation. The consultations enabled and motivated by the *Ripple* project suggested that the difficulties for small practices to undertake geometrically complex projects are significant. If they are to be overcome, further work at multiple levels is necessary. Given the amount of architecture designed by small local firms, and their influence within the local communities, this work appears to be important.

As a preliminary suggestion, this paper proposes optioneering as a useful attitude towards local and small-scale architectural designing that utilises contemporary computation. This attitude appears productive because it suggests flexible and opportunistic methodologies that make the best use of available skills and technologies. In the case of Melbourne, we discovered available expertise, technology and – crucially – considerable enthusiasm towards computationally sustained explorations. This enthusiasm suggests that a way forward can be via the community driven effort towards a supportive ecosystem of stakeholders. Indeed, we are actively participating in such efforts. To date, they include a local case-study discussion group (Computational Design Group, Melbourne) and an institution-agnostic education initiative (ExLab, or Experimental Design lab) but the discussion of these will have to be reserved for future publications.

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