Myths and realities of prefabrication for post-disaster reconstruction

Colin Davidson, Université de Montréal (corresponding author)
e-mail: colinhdavidson@symmpatico.ca

Gonzalo Lizarralde, Université de Montréal
e-mail: gonzalo.lizarralde@umontreal.ca

Cassidy Johnson, University College (London)
e-mail: cassidy.johnson@ucl.ac.uk

Abstract

Prefabrication is usually associated with one of the two prevailing approaches to post-disaster reconstruction, the "top-down approach". However, this is based on a narrow view of prefabrication, which associates it with high-tech and highly industrialized initiatives.

"Prefabrication" literally means carrying out work *earlier* (typically moving it from the site to a controlled work environment), aiming for a better use of resources and improved control, and reducing skill-requiring operations on site - all in the interest of speed and profit. All building work uses *materials* (like sand, concrete, earth, formed on site) and *components* (units like bricks, sections like joists or assemblies like windows, necessarily prefabricated). Conventional prefabrication in high-tech and industrialized environments involves centralized factories, novel materials and stable organizations, but this is not necessarily the case in other environments.

Post-disaster reconstruction often includes a huge and disorganized demand, which agencies and governments want to meet rapidly; but there is the endemic risk of profiteering and price gouging. Nonetheless, local residents and companies are willing to intervene, if only they knew how. The questions then are: how can local resources resource be supported to perform better? And, is there scope for prefabrication in some form or other in such a context?

A form of prefabrication already exists in developing countries, which uses local materials and avoids high-tech industrialized operations, and which is based on a multiplication of resources such as small-scale local entrepreneurs. Facilitating a decentralized, low-tech, homegrown prefabrication capability of this sort may significantly contribute to post-disaster reconstruction.

Key words: Construction demand; Micro-enterprises; Organization; Local resources; Prefabrication.

Introduction

Scenarios of post-disaster reconstruction contain all the ingredients for producing inadequate building solutions – notably because of the need for rapid and large-scale action under conditions of physical chaos and administrative disorganization. These conditions, of course, are well known, but their consequences for the necessary rebuilding activities are less familiar.

At the best of times, building is an activity fraught with risks. As Davidson (1988: 512) wrote:

> The traditional building team is a temporary grouping of independent entities brought together by certain contracts to carry out tasks of design and construction, which comprise its mission. It is characterized by its dispersion and its discontinuity. The building team is dispersed because of the nature of the contracts, which establish direct links between certain participants only. […] The building team is also discontinuous because it exists only for the duration of the design and construction process, after which team members become involved in other projects with other firms.

The building industry, therefore, responds on a project-by-project basis to demands placed on it by individual clients – corporative, governmental and individual – for institutional, industrial or residential facilities. At best, the individual enterprises within this industry (justly called a *multi-industry* because of its diversified composition) can plan ahead by assessing the trends in the market place or those sectors of it they feel suit them best. Indeed, great skill is required for a professional agency or construction firm to survive in such a market, particularly as governments tend to use the construction sector as an economic regulator, e.g. by constantly toying with interest rates. In such a context, it is hardly surprising that up-front investment in innovation, such as prefabrication, is rare; potential innovators (a) wait for inducements such as government purchasing programs and market aggregation, and then (b) adjust their prices to reflect "what the market will bear" – irrespective of their actual costs. Significantly, according to the United Nations (1953), traditional building is characterized by the need for skill, both in the execution of work and the interpretation of instructions.

Against this backdrop, where does prefabrication fit in, and, in particular, into post-disaster reconstruction – where conditions of predictability are almost totally absent?

This paper looks at prefabrication in post-disaster reconstruction, primarily in terms of organizational design. First, prefabrication is situated in its typical contemporary context. Secondly, an alternative form of prefabrication adapted for the social development and reconstruction context is presented and illustrated by research precedents and a case history. Finally, strategies - and preconditions - for mobilizing the potential resources of prefabrication to meet the challenges of reconstruction are proposed and potential benefits outlined. The aim is to examine what might be its potential and its limitations in the reconstruction context.

The underlying assumption is that prefabrication, with its scope for *quantity* production of easy-to-assemble building products, potentially offers a good resource for meeting the *quantity* demands of post-disaster reconstruction. It is however recognized that behind the quantitative aspects of reconstruction lie complex social and cultural requirements, implicit at both at the community and the family levels.

Antecedents: short history of research in the building industry

Over a number of years – particularly during the two decades of the ’60s and ’70s - hands-on action research was conducted in several institutes, accompanied by theoretical analyses involving the systems approach to building process innovation and particularly to prefabrication. This approach implies not only taking part in, observing and recording various technical approaches, but also assessing the interaction between them and their successes (or failures), and the concomitant ‘design’ of the organization that initiated them. Considering the major technical advances in other industries such as telecommunications, aviation, and space exploration, it is not surprising that a remarkable optimism on the potential of industrialized methods characterized research in the building industry during this time. Furthermore, low-cost housing in both industrialized countries and in developing nations was a common field of exploration to test the multiple advantages of mass production and economies of scale provided by industrialized solutions (Centre de Création Industrielle, 1983).

The successes and failures of some of the early solutions of industrialized construction led to formulating an oft-verified hypothesis, namely that the success of a technical innovation in a given context is a direct function of the suitability of the organizational design that accompanies it.

Over the same period, and also continuing through the ’80s and ’90s, this approach to observing the construction process and its major trends was extended to include the study of strategic procurement, namely the way building owners make their project purchasing decisions and how these decisions establish a framework within which the participants in the ensuing projects organize their work (Masterman, 2002; Johnson *et al*., 2005).

The decades of the ‘80s and ‘90s also brought radical opposition to the use of standardized industrialized solutions to building problems in developing countries, particularly regarding low-cost housing. Opponents of high-tech prefabrication and industrialized solutions gathered considerable evidence of the multiple failures of standardized solutions in Turkey, Peru, Nicaragua, and Africa. The peak of this opposition came when UNDRO (1982: 34) claimed that reconstruction initiatives should avoid “designing, manufacturing and stockpiling prefabricated emergency shelter units (other than tents), as this solution is too costly and a waste of resources for developing countries".

In parallel and from the late '80s, the initiation, planning and management of construction projects became a professional activity on its own. The proliferation of programs of project management in various disciplines (Information technology, public health, aviation, etc.) also influenced the construction sector. The management of construction processes then became a professional specialization and a subject of research suitable for architects and engineers. Because of their capacities of negotiation, mediation, and risk anticipation, project managers have recently become important protagonists of organizational design, articulating the otherwise fragmented worlds of design and construction.

Research methods

This research project aimed at transposing the analysis of the building industry to the organization of the building process and to the specific context of post-disaster reconstruction, where exactly the same principles were found to apply – but with much greater difficulty, if only because of the greater number of parties involved, the prevailing chaos, and the need for speed (often in the absence of up-front planning).

Initially, an extensive review of prefabricated housing solutions for low-cost housing in developing countries was conducted. The case study research was conducted between June and December 2007. It implied the direct participation of one of the authors in the object of study (as proposed by Marshall and Rossman, 1999; Robson, 2002). The fieldwork concentrated on the technical solutions informally developed in the South African townships, particularly on the informal pre-fab. companies present in the township of Kayelitsha (Cape Town). Articles and press releases related to this industry were collected. Two of these companies were visited in July and in November 2006. The personal contacts established with one of the owners and with salesmen proved to be extremely useful in guaranteeing that the researchers had good access to information.

Hypotheses were first tested through an analysis of published information and comparison of data from previous research, and then they were tested with qualitative data from the detailed case study. Following the approach suggested by Robert Yin (1984) it was possible to generate patterns and to identify relations of theoretical importance, leading to formulating "analytical generalizations". The research included the following activities:

1. Collection of information about pre-fabricated solutions in both developed and developing countries.
2. Analysis of prefabricated solutions existing in developing countries.
3. Analysis of patterns found in the case study.
4. Comparison of patterns found in activity 3 with previous research results and patterns.
5. Definition of analytical generalizations following from the case study approach (Yin, 1984).

Research question:

- Given the nature of the construction industry and its organization worldwide, how can it best be mobilized to improve the post-disaster reconstruction process?
- In such a context, is prefabrication a reasonable approach and if so, how?

Research findings

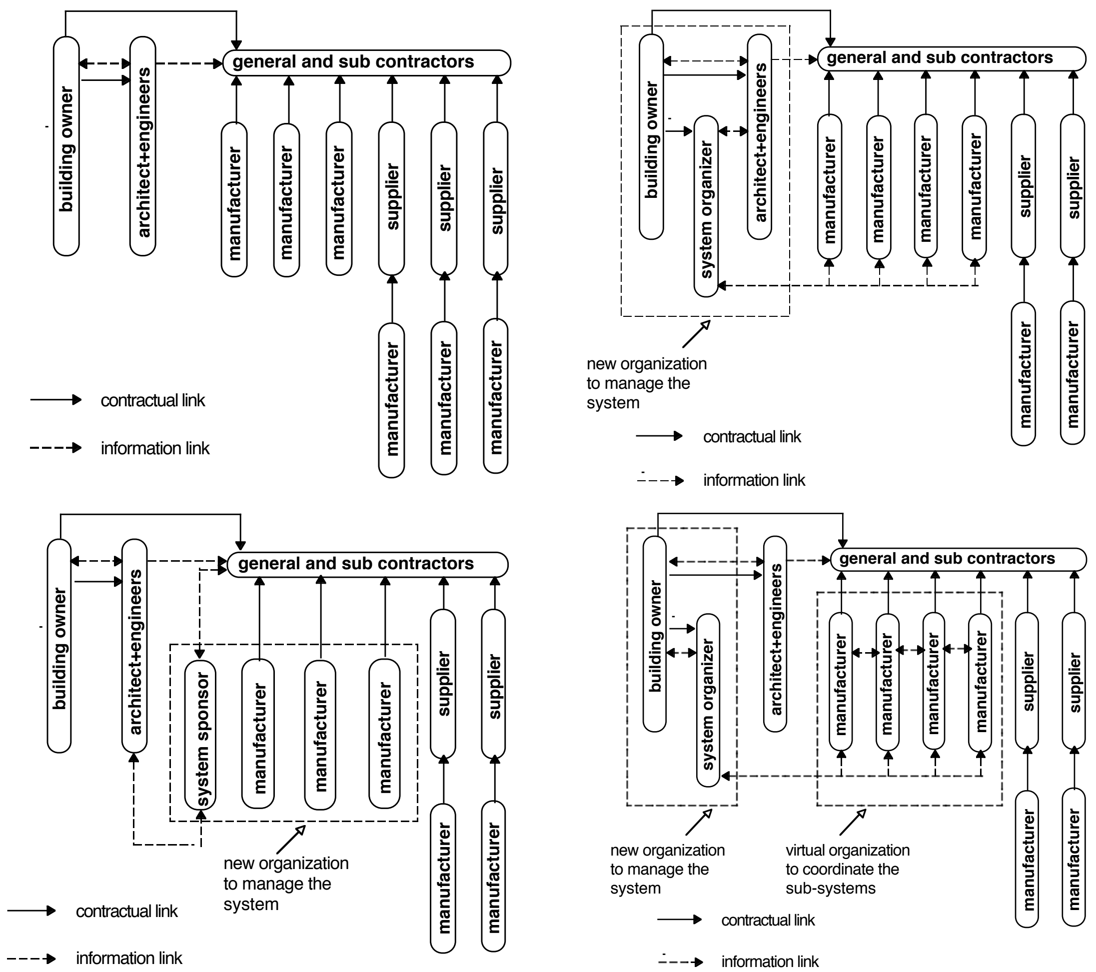
1. Regarding prefabrication: the conventional view

The literature describing prefabricated systems of building at a technical level is abundant (Deeson, 1965; Lugez, 1973; Richard, 1990, 2003). In brief, prefabrication describes a method of building where a significant part of the construction work is done earlier, typically prior to site delivery and assembly. What form these 'pre-fabricated' parts take depends on the technical resources that are available for the system's initiator and on the nature of the target market. In technical terms, there is a continuum ranging, for example, from prefabricated sectional houses or room boxes, to kits of small, integrated component parts. In all cases, the aim is to shift work away from the difficulties of the site, with its difficult working conditions and its requirement for skilled workmanship (see the reference above to UN, 1953), leaving only un- or semi-skilled assembly operations on site. This aim is attained through up-front investment in production capacity – greater if the component parts are more complex or larger, smaller with the use of the kits-of-parts approaches.

However, as has been mentioned, technical change is (or should be) accompanied by organizational change; some examples are schematically illustrated in fig. 1, next page.

It will be seen from Fig. 1, (upper left) that in the traditional situation, the building team (described above as *discontinuous* and *dispersed*), there are few links between the participants, corresponding to the way the contracts are set up between the participants; on the other hand, each organizational variant (lower left, and upper and lower right) presents one or two new organizations and set of new links, corresponding to shifts in the sharing of responsibilities and opening the door for the necessary longer term collaboration that must precede up-front investment in production capabilities.

What is important to retain from these examples - in their context of innovation in the *relative* stability of construction in stable economic conditions – is the mechanisms used to increase control (by the innovating party) over the unknowns of the building process.



Source: Glover, 1974, pp 15-18

Fig. 1. Organizaton of the building process. (Upper left): for the purpose of comparison: organization of the traditional building team, showing participants and the principal links between them. (Lower left, and right): organization variants accompanying successful applications of prefabrication.

The question is, therefore: is there any scope for this sort of approach in the context of post-disaster reconstruction – that is to say, in the presence (a) of a composite multi-faced “client”, including beneficiaries, ONGs (local and national), local and regional governments, representatives of donor countries, charitable and religious entities etc., and (b) of specific customs regarding procurement, contracting and inter-enterprise agreements[1] (customs that are probably different from current practice in donor countries). The first reaction is that to introduce novel forms of prefabrication into such a context is even more risky than within a more stable regional or national market. This reaction is amply argued in Shelter after Disasters (UNDRO, 1982).

1 Often, these customs are inherited from former occupying colonial powers and are still applied with a stultifying rigor and much red tape.

2. An alternative view of prefabrication

Post-disaster reconstruction occurs with *predictable unpredictability*; disasters such as hurricanes recur annually (but with unknown force and varied trajectories), earthquakes are frequent (but not necessarily in the same localities), mudslides and floods accompany heavy rains (which sometimes follow seasonal cycles). In other words, efforts to take precautionary measures compete with available resources, probably already allocated for predictable problems within known timeframes.

Be that as it may, the aftermath of a disaster presents several building industry-related characteristics that have an impact on the issue being raised here: (i) while, as has already been mentioned, there is a need for a large quantity of building – both temporary and permanent – within a very tight time frame, (ii) there are administrative obstacles to formal construction interventions – whether by local or international NGOs and donor bodies, and (iii) there can be debate about the best approach – top-down with imported houses *versus* bottom-up using sweat-equity local labor. In other words, the actual production of homes is likely to be a trickle compared to the extent of the immediate need. Can this bottleneck be avoided?

Families in need of shelter and rebuilding are often capable of helping themselves, if provided with the means (i.e. physical and knowledge resources) (Turner, 1972). The problem shifts from recognizing the bottleneck to finding a way to exploit this survival spirit. How?

Fig. 2. Informal prefabrication in developing countries. Left: A slum in Bogota, Colombia (note the self-built house using a system of pre-fab. panels). Right: Omar Vasquez carries off a door his father recovered from the wreckage of their home. Usulutàn, El Salvador (Source right: Global Ministries - United Methodist Church, http://gbgm umc.org/photogallery).

Four previous studies point to potential solutions to this problem.

First, Reinaldo Roesch da Silva (1980) noted that in many aided self-help housing development projects, the urban poor (that was his subject) are capable of providing far more input than the physical effort of building (including the time-consuming phase of acquiring the necessary skills); he suggested that, given the opportunity in a systematic way, they were able to participate in many decision phases related to their housing project (their future house or the future grouped homes of their immediate community), including choosing design options, scheduling and even – up to a point – project financing.

Second, Emilio Gamboa Gomez (1987) proposed a construction system of light-weight modular formwork *system* which could be loaned by the municipality (Mexico City in his example) to communities planning to develop a neighborhood (e.g. by an organized "invasion" of apparently vacant land). Coupled with simple instructions and assisted by a supervisor, community members were pro vided with a tool to produce houses which met a minimum of performances and which could be adjusted to their individual requirements (within the limits of the system, of course). This approach builds on the observation that those who are planning an "invasion" possess the capabilities described by Roesch da Silva (1980).

Third, an ambitious program conducted by CYTED in the 1980's demonstrated that low-tech prefabrication already plays a fundamental role in construction in developing countries (Kellett and Franco, 1993). The evaluation of this program, conducted by Kellett and Franco (1993) demonstrated that (i) various low-tech prefabricated solutions for low-cost housing are widely used in Colombia, Chile and Peru; and (ii) some of these systems already include large degree of participation from users. They explain:

> "Several of the projects within the CYTED umbrella have successfully developed the potential of industrialization and prefabrication to produce construction components in small-scale community-organized workshops […] Such enterprises have the double potential advantage of increasing employment as well as improving housing conditions." (pp. 52)

Fourth, in a comprehensive research project, Stallen, Chabannes and Steinberg (1994) demonstrated that, contrary to common belief, prefabrication "is not exclusively based on high technology approaches but is in fact appropriate and advantageous to low-income communities and self-help builders" (p. 13). In fact these authors demonstrated that low-tech forms of prefabrication are already widely used in China, Colombia, India, Mexico and Nicaragua. Some of the companies studied had produced more than 1 million m2 of housing, technologies varied from bamboo panels to reinforced and pre-stressed concrete slabs. They concluded that - because of its capacity to develop and use local resources - light small-scale prefabrication is part of the housing solution in developing countries.

Case study

This case study reports part of the results obtained in a research project conducted in the townships of Cape Town, South Africa (Lizarralde and Root, 2008). This research uncovered the emerging industry of low-cost portable shelters, still largely ignored in the literature. It reported on the existence of two informal construction companies well established in the townships of Kayelisha and Mfuleni (referred to as the "Kayelitsha Shacks" and the "Township Shacks").

Kayelitsha Shacks has been in the 'business' for more than seven years; it delivers an average of 20 shacks per month and employs 3 people from the townships. Initially a self-help builder, the owner and manager of the company soon realized that he could buy additional recycled and new material and sell more pre-fab. units. The owner now owns a truck, a shabeen (informal canteen in the townships) and a house in a well established middle class neighborhood in the coastline. The business is based in Kayelitsha but it also serves other townships of the Cape Town area (Mfuleni, Mitchel's Plain, Guguletu, Hout Bay, etc). The company offers product delivery and service to the periphery of Cape Town (including the town of Stellenbosch, a one and a half hour drive from Kayelitsha). Township Shacks is also based in Kayelitsha but it has a selling point in Mfuleni with an employee is in charge.

The most popular product of these companies is the corrugated metal sheet standard shack of 3 by 2,6 m with a sloped roof (see Fig. 3). This portable unit includes a simple wood window and a door and is sold for R1,900[2] with a required deposit of at least R500. Other products include the double shack (3 by 5,2 for R3,900) and customized units for special orders. All the products include transportation to the site and installation. Because the panels can be easily dismounted for transportation, the single shack is installed in less than 30 minutes by nailing together the four panels and the roof.

The panels are made of different types of corrugated iron sheets (different thicknesses and different profiles). They also combine new and recycled materials, but the best sheets (usually new) are often used for the roof in order to avoid water leaks.

The owner of Kayelitsha Shacks buys both recycled and new materials, taking advantage of best prices in the market. He then stocks the corrugated sheets, the spare sheets and the wood in the yard in Kayelitsha. The marketing strategy consists of assembling some panels to exhibit some simulated finished houses on the sidewalk of the main road. About 10 shacks are exhibited in the main access road to Kayelitsha where at least four other companies are established (see Figs 3 and 4). Despite the fact that only minor differences exist between the products and prices of different companies, the proximity of them and the exhibition of their units potentially permits the clients to do 'shopping' and to select the provider they prefer. Clients are easily attracted by the colorful demonstration pre-fab. Units.

When a house is purchased (and the deposit paid) then the owner uses the deposit to buy the materials required for the roof, the window and the door.

2. 7,155 South African Rands (R) = 1 USD, January 28, 2008.

These components are not usually stocked in large quantities and are often obtained only when the transaction has been confirmed (and the deposit has been secured). The employees then deliver the product by truck and assemble the unit on site.

Township Shacks also has a pick-up truck for transporting the units. However, it also uses a modified shopping trolley to transport small materials and short distances in the branch in Mfuleni (see Fig. 4).

These innovative companies work in a very hostile environment. One of the most important constraints for informal business growth is financing. The owner of Kayelitsha Shacks argues that his limited possibilities to acquire credit largely limits his capacity to keep more materials in stock and to profit from good prices (by buying in large numbers and during good sales).

Over time, the units are usually modified by the users. Frequent alterations include adding internal panels in wood or cardboard to increase the thermal insulation of the envelope, and adding more modules to comprise a larger house.


Fig. 3. The products of Kayelitsha Shacks and Township Shacks. Right: Exhibition of pre-fab shacks from different companies in Lansdowne, a main road in Kayelitsha.


Fig. 4. Transportation means used by Kayelitsha Shacks (left) and Township Shacks (right)

The 9 sq m. portable house includes a corrugated-metal sheet box, a roof, a door and a window but does not include a floor. “Floors and foundations are an obstacle for our clients” explains the owner of this firm of pre-fab. shacks in Cape Town. “Users move very often and an investment in foundations and floor is therefore a waste of money”. The pre-fab. shacks – on the other hand - provide them maximum flexibility. They are light, easy to assemble, easy to transport, strong and easy to modify.

By basing their products on a simple module, a simplified process, a specialized service and efficient delivery, these informal construction companies demonstrate a strong capacity to respond and to adapt to the hostile conditions of the lowest housing market in developing countries. Bhatt and Rybczynski (2003), argue that the informal sector, which maximizes self-help and mutual aid building, has been virtually the only group that has had any success in providing appropriate, low cost solutions to the shelter problems of the urban poor. However, the informal sector in developing countries is rarely seen as a solution and it is rather perceived as an urban anomaly that needs to be replaced by formal processes and companies. “The state is forced to tolerate and accommodate a certain degree of illegality and irregularity” explain Keivani and Werna (2001:194).

Discussion

The informal companies of the South African construction industry have managed to develop a product that responds to the affordability levels of the poorest sector of the population while responding to the constant changes of the users. This product is flexible, adaptable, portable, light and durable. In a hostile financial and legal environment, these companies have demonstrated a strong capacity to innovate by combining a simplified process with an improved and environmentally friendly technical solution. These solutions take full advantage of variety, multiplicity, recycling and adaptability.

Post-disaster reconstruction, closely associated with providing resilience, suffers from the bottlenecks inherent in formal procedures while passing by the available self-help resources. Choosing the formal route may ensure building housing of “adequate” quality[3]; choosing the usual self-help route involves survivors in lengthy construction activities, often preventing them from starting up other recovery-related activities and employment (Sliwinsky, 2007).

The argument here is that what can be called “grass-roots prefabrication” may provide the bridge to semi-structured reconstruction using available human resources effectively. As the South African example showed, a community-based prefabricator makes low-cost products available for building (or rebuilding) without the need for the rare building industry skills, while providing

3. The identification of what is “adequate” is probably difficult in the context of formal building processes, with their limited time horizon for project completion and their subservience to recognized and approved norms.

houses with a level of performance that is comparable to or slightly better than the prevailing standard in the community. This example also showed that the up-front investment is in organization with only a minimum investment in facilities and equipment.

The prerequisite is the existence of a decentralized set of a prefabrication enterprises organized in such a way that they can survive the natural disaster itself.

This is a key aspect of resilience building – ensuring that within an exposed community there is a prefabrication capability, useful for community development when there is no disaster and necessary after a catastrophe.

Key Lessons Learned

- Prefabrication 'normally' involves up-front investment in technical innovation, accompanied by organizational design, and benefits from a relatively stable market environment.
- Reconstruction 'normally' does not benefit from the full potential of the survivors to participate in rebuilding their homes.
- Grass-roots, low-tech and decentralized prefabrication provides the survivors with a tool to enhance their participation.
- Encouraging the establishment of small prefabrication enterprises is properly part of a community-based resilience policy.

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Authors' biographies

Emeritus Professor and architect, Colin Davidson taught and conducted research at the Faculty of Environmental Design (Faculté de l'aménagement") at the University of Montreal, where he was Dean from 1975 to 1985, and where he is responsible for the graduate programs in Project initiation and management ("Montage et gestion de projets d'aménagement"). Prof. Davidson's research brings a systems approach to project organization and procurement, information and communications within the building team, and to reconstruction after natural disasters in developing countries. Prof. Davidson has participated in the work of various CIB commissions, including coordinating W102, since 1972. He has also practiced in the U.K., the USA and Italy.

Dr. Gonzalo Lizarralde is a specialist in management, implementation and evaluation of architectural projects. He has long experience of research and consulting for architecture and construction projects particularly in the field of low-cost housing. Dr. Lizarralde has taught at the University of Cape Town, McGill University, Université de Montréal and Universidad Javeriana and has lectured in universities in Europe, USA and Latin America. He has a PhD from the Université de Montréal and a post doctorate from the Department of Construction Economics and Management of the University of Cape Town. He is the director of the grif – The IF Research Group of Université de Montréal.

Cassidy Johnson has a background in urban development and minimum cost housing, with a focus on urbanization in developing countries. She is a lecturer at the Development Planning Unit, University College London and a research fellow at the Earth Institute at Columbia University. She holds a PhD from the Université de Montréal. Her research interests are disaster mitigation and reconstruction, looking at how communities and governments can prepare urban areas to be resilient to and recover from disasters. She has done research on post-disaster temporary housing - particularly looking at disaster recovery in Turkey, and on urban rehabilitation and Romani communities in Istanbul. She is a founding member of i-Rec and coordinator of CIB TG 63 Disasters and the Built Environment.