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INTERPRETING RESOURCING BOTTLENECKS OF POST-WENCHUAN EARTHQUAKE RECONSTRUCTION IN CHINA

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Received 18 July 2010; accepted 28 October 2010

ABSTRACT. Post-disaster reconstruction is likely to suffer resource shortages and supply disruptions. The devastating Wenchuan earthquake on 12 May 2008 in China served as a typical example. After the catastrophe, resource problems such as price escalation and market inflation posed a significant challenge to Chinese policy makers and reconstruction team. Based on field surveys, the study attempts to examine the Wenchuan earthquake reconstruction practice and identify the most vulnerable resources along with their resourcing impediments inherent in the reconstruction process. The research findings show that at the early stage of reconstruction, labour and materials such as brick, cement, steel and aggregate were the most needed yet vulnerable resources. Procurement of these resources was mainly hindered by (1) reconstruction schedule and speed, (2) the impacts of the 2008 global financial crisis, (3) inadequate local transportation capacity, (4) dysfunction of the construction market, and (5) insufficient engagement of local construction industry. While the interventions and measures Chinese government adopted after the earthquake seem to be able to deal with resourcing bottlenecks in a short time; different efforts to reduce the impacts of these five areas are needed with a view to expediting longer-term disaster recovery and reconstruction.

KEYWORDS: Post-disaster reconstruction; Resource availability; Resourcing constraints; Wenchuan earthquake; China

1. INTRODUCTION

On 12 May 2008 a magnitude (M) 8.0[1] earthquake struck the Sichuan Province of China and the neighbouring Provinces of Gansu and

[1] M 8.0 represents surface wave magnitude (Ms), the national standard used by the Chinese government for earthquake magnitude. M7.9 for the Wenchuan Earthquake from The United States Geological Survey (USGS) reports represents moment magnitude (Mw).

International Journal of Strategic Property Management
ISSN 1648-715X print / ISSN 1648-9179 online
http://www.ijspm.vgtu.lt
DOI: 10.3846/ijspm.2010.24

Shannxi. The Wenchuan earthquake, as it is commonly known, killed 69,266 people, injured 374,643 people and left 17,923 people missing[2]. The earthquake caused widespread destruction to buildings and infrastructure. The epicentre was in Wenchuan County, a rural and mountainous region in Sichuan Province, around 50 miles (80 kilometres) from the capital city Chengdu. More than 15 million housing units collapsed during the earthquake resulting in direct monetary losses to the buildings and infrastructure of over US$150 billion (Paterson et al., 2008). Approximately 34,125 kilometres of highway, 1,263 reservoirs, 7,444 schools, 11,028 medical institutions, numerous urban and rural residences and factories were devastated by the earthquake with the direct economic losses reaching US$123.66 billion (State Planning Group, 2008). In the earthquake, housing was the single greatest component of all losses in terms of economic value and buildings damaged.

As the overall earthquake reconstruction unfolded in August 2008, compounding the economic impacts in the disaster-hit region was the local mounting demand for construction necessities such as skills, materials, and machinery. A shortage of building materials posed a significant obstacle to housing sector. Labour scarcity was another problem leading to a precipitous increase in wages. The disproportionate imbalance between the reconstruction demand and the existing supply capacity led to soaring price escalation and intensive inflation strain in the earthquake impacted areas.

Against this backdrop, this paper aims to understand the issues arising during the post-Wenchuan earthquake reconstruction that had an impact on resource procurement for housing recovery in China. Based on in-field observations and semi-structured interviews, the research examines the resourcing practice for housing reconstruction conducted by the building practitioners following the event. The research findings show that at the early stage of housing reconstruction, lack of resources including labour force and materials such as brick, cement, steel and aggregate, to a great extent, obstructed the housing recovery. Procurement for these resources was mainly constraint by emerging issues such as (1) reconstruction schedule and speed, (2) the impacts of the 2008 global financial crisis, (3) inadequate local transportation capacity, (4) dysfunction of the construction market, and (5) insufficient engagement of local construction industry. Despite government-led interventions and measures imposed into the construction market for a temporary relief of post-disaster inflation, longer-term policy innovations and key stakeholders' participation are needed with a view to fully addressing resourcing challenges confronted in the future. This paper provides an overview of the key elements that made resourcing for housing reconstruction such a complex undertaking in a government-driven recovery environment. The empirical result and discussion in the paper are hoped to draw attention from those recovery planners and practitioners to the identified five areas and inform their disaster recovery efforts.

2. RESOURCE AVAILABILITY FOR POST-DISASTER RECONSTRUCTION

The adoption of the Hyogo Declaration and the *Hyogo Framework for Action 2005-2015 (HFFA): Building the Resilience of Nations and Communities to Disasters* (ISDR, 2005) in 2005 and, towards this goal, the establishment of the *Global Platform for Disaster Risk Reduction* in 2006 underlined the crucial role of reducing risks and strengthening community resilience to disasters. However, even with this framework

[2] As of September 11, 2008 noon.

in place, the first five years (2005-2010) has seen an increased number of the deadliest disasters in human history. The events tabulated in Table 1 can be seen as representative of disastrous catastrophes during this period standing out people's images in terms of the human loss and the financial burden involved as a result of a disaster.

The figures in Table 1 are statistically in line with Cutter and Emrich (2006)'s observation that hazard vulnerability is increasing, not decreasing, and is not evenly distributed geographically and socially. Antecedent evidence shows that when media and public attention have receded in a disaster impacted area; the survivals have often been left to confront the other significant challenges of recovering from disaster. Amongst all the recovery elements, housing, as one of the basic human needs, is always placed as the top priority in a country's recovery agenda (Oliver-Smith, 1990; Comerio, 1997; Brezar, 2005). However, the complexity and uncertainty of a post-disaster environment determines that the delivery process of a housing rebuilding project is often more complex and difficult than it is for conventional projects (Alexander, 2004). As such, existing construction procurement techniques are less likely to handle the increased complexity of a reconstruction project (Barakat, 2003; Masurier et al., 2006; Jha et al., 2010).

During last decade, research has focused attention on exploring the efforts to improve the performance of reconstruction projects (e.g. Ofori, 2002; Lizarralde, 2004; Lorch, 2005; Makhanu, 2006; Ahmed, 2008; Mumtaz et al., 2008), advocating a series of community and government initiatives (e.g. Schilderman, 2004; Wu and Lindell, 2004; Burby, 2005; Kenny, 2007; James, 2008). However, the underlying implications of disasters for longer term reconstruction are not fully understood by recovery practitioners in both developing and developed countries. Specifically, the inadequacy of construction resources and the capability to rebuild housing along with the disaster's impact on the recovery process has been largely overlooked.

For instance, after the 2004 Indian Ocean tsunami, a lack of building materials such as sand, stone, cement, timber and brick in Indonesia created a major bottleneck for housing recovery (ADB, 2007; Nazara and Resosudarmo, 2007; Zuo and Wilkinson, 2008). The shortage of aggregate, human resources and heavy equipment has been identified as one of the potential constraints to the recovery process in New Zealand if a large-scale disaster were to strike (Brunsdon and Smith, 2004; Singh, 2007). Moreover, one of the longer term effects caused by resource shortages after a disaster is 'socio-economic displacement',

Table 1. Human and economic loss of major disasters between 2005 and 2010

Disastrous event (2005-2010)	Hurricane Katrina	Great Pakistan Earthquake	Cyclone Nargis	Wenchuan Earthquake	'Black Saturday' Bushfires	Haiti Earthquake
Time	Aug. 2005	Oct. 2005	May 2008	May 2008	Feb. 2009	Jan. 2010
Country	US	Pakistan	Myanmar	China	Australia	Haiti
Death toll	1836	90,000	85,000	69,266	173	230,000
Economic loss[1]	$138 billion	$5 billion	$4 billion	$123.69 billion	$1.3 billion	NA

Note: 1. US dollars; NA: not available

Source: Munich Re (2008), Munich Re (2009), Guy Carpenter's Instrat (2006), State Planning Group (2008), VBBRA (2009)

which was manifested in tsunami impacted Indonesia and Sri Lanka in forms of inflationary chaos (Jayasuriya et al., 2005; Nazara and Resosudarmo, 2007), 'Dutch Disease'[3] (Adam and Bevan, 2004), and cost surge (Jayasuriya and McCawley, 2008). The most extreme effect of resource shortages and limited access to recovery resources occurred following the 2004 Indian Ocean tsunami. As Jayasuriya et al. (2005) observed in Sri Lanka, the impact of the tsunami intensified resource shortages that existed pre-event, fuelled inflation, constrained the government's fiscal capacity, and adversely affected housing reconstruction. These problems, however, combined with procurement deficiencies of the implementing agencies and resourcing-induced environmental degradation, reduced the overall effectiveness of recovery in tsunami-impacted countries (UNDP, 2005; IFRC, 2006).

On the other hand, a number of experiences have shown positive results when resource bottlenecks are dealt with by appropriate post-disaster policies. Taking the Tangshan earthquake (1976) recovery as an illustration, resourcing in this situation was not a threat to post-quake physical reconstruction whereby, "*A master plan was formulated, heavy equipment was purchased and industrial plants were established to produce reconstruction materials*" (Mitchell, 2004, p. 52). Apart from the above examples, there have been few studies that looked at resource planning and preparedness for long-term post-disaster reconstruction (Alexander, 2004; Orabi et al., 2009). Many studies concerned with resource deployment and allocation are targeted mainly at emergency response to meet short-term humanitarian relief needs after a disaster (e.g. Perry and Lindell, 2003; Thompson et al., 2006; Troy et al., 2008). However, a number of scholars such as Ye and Okada (2002) and Sullivan (2003) have recognized that desirable post-disaster reconstruction could only be made possible by systematic recovery planning with a focus on making the resources required available for long-term reconstruction. In addition, when examining their post-tsunami reconstruction involvement, many NGOs, INGOs such as IFRC (2006) and the UN agencies such as UNDP (2005; 2006) also highlighted the importance of resource availability as being an integral element in the ultimate efficacy of post-disaster recovery efforts. While these findings have clear implications for resourcing reconstruction, little empirical research has demonstrated the underlying resource vulnerabilities and constraints inherent in the reconstruction process when sourcing resources for housing projects.

This paper aims to contribute to fill this gap by examining a contemporary case study. An empirical analysis, based largely on China's Wenchuan earthquake rebuilding experience, of the resourcing practice and bottlenecks during post-quake reconstruction is presented. By using in-field surveys, specific resourcing-related constraints that obstructed the post-disaster reconstruction along with the vulnerable resources were identified in this research to inform further thinking and actions of reconstruction stakeholders and involved practitioners.

[3] Whenever a particular sector in a particular economy experiences a marked boom, the demand for inputs used in that sector tends to increase. This increased demand, in turn, tends to cause negative impacts for other industries that compete for the inputs used in the booming sector. The increased prices of inputs raise costs and reduce profitability in the competing (non-booming) industries. The resulting negative impact on the non-booming sectors is known as 'Dutch Disease', named after the experience in the Netherlands of de-industrialization in the wake of large inflows of export revenues from North Sea Oil in the last 1970s.

3. RESEARCH METHODS

In the wake of the Wenchuan earthquake, contrary to convention, the openness in China allowed the 'Resilient Organisations' research team to undertake a series of field trips to the earthquake impacted areas in China. We were able to access grounded information and to conduct a substantial research concerning resourcing for post-earthquake housing reconstruction in China. This paper is reported based on the data collected from the field trip conducted between December 2008 and February 2009.

Given the exploratory nature of the study, field-based qualitative methods were adopted including on-site observations, in-depth interviews along with desk review of policy documents and media publications. During the Wenchuan earthquake, as was observed by the researchers, the construction practitioners played a major role in resourcing housing reconstruction for the affected populations. The focus of this study, therefore, is placed on contractor-led resource procurement for Wenchuan earthquake housing reconstruction. Apart from views of these industry players, the research necessitates a comprehensive spectrum of experiences, capturing disaster perspectives of other main stakeholders related to resourcing after a disastrous event, such as decision makers, academicians and businesses.

The survey population in this research was primarily selected based on informants' experience and knowledge with providing resourcing services for housing recovery. The professional and educational attainment levels of the informants also vary. As the anonymity of the informants needs to be protected, all the citations in this paper are presented without identifying relevant information concerning the respondent. In the case of a quote being issued to substantiate a point, the informant will be quoted by the code, position or organisation and, to maintain confidentiality, all use of names is avoided. The basic profile of the interviewees is shown in Table 2.

Table 2. Profile of the interviewees

Interviewee Code	Description
Group1	*Specialization*
C1-C4	Project managers
C5-C13	Resource procurement managers
Group2	*Source of resource supply*
B1-B4	Construction material retailers
Group3	*Research Area*
R1-R2	Construction material
R3-R4	Construction procurement
Group4	*Main Responsibility*
G1	Construction market transaction regulation
G2-G3	Post-quake reconstruction supervision
G4	Transport planning

Within the interviews, qualitative data was captured around the following questions:

1. What were the most vulnerable resources in post-Wenchuan earthquake reconstruction?
2. What initiatives had been taken to address resourcing difficulties in China?
3. What were constraints to contractor-led resource procurement?
4. What need to be addressed in the future to enhance resource availability for post-disaster reconstruction?

The interview survey was semi-structured, allowing us to probe areas that open during the discussion (Hussey and Hussey, 1997; Fellows and Liu, 2003). The average interview length of each interviewee in this study

was sixty minutes. Follow-up telephone calls and e-mail and mail correspondences to a number of interviewees ensured the validity and accuracy of the research findings. The interview records were transcribed, coded, and analyzed by using comparison of queries. The similar comments and quotations from interviewees under a same question are analyzed and synthesized. The presence of data such as examples, comments and suggestions in the paper was approved by the related respondents. The remainder of the paper presents the research findings in terms of the identified (1) most vulnerable reconstruction resources in the wake of the Wenchuan earthquake, (2) measures adopted by the Chinese government in order to address resource bottlenecks, and (3) resourcing constraints inherent in the post-earthquake reconstruction process.

4. RESULTS AND DISCUSSION

4.1. Most vulnerable resources

According to a number of the interviewees, at the early stage of post-Wenchuan earthquake reconstruction, most material production facilities damaged from the earthquake were still in a paralyzed state. The significant earthquake impacts on the local production capacity created disproportionate imbalance between demand and supply of the common building materials and manpower, resulting in soaring price escalation. During the interviews, the respondents identified the most needed construction materials for housing rebuilding after the quake. These most vulnerable materials were brick, cement, aggregate, with 127%, 30%, and 125% price increase respectively, and steel, with 30% price decrease by February in comparison with the pre-event level[4].

[4] Price contrast between in April 2008 pre-earthquake and in February 2009 post-earthquake.

Based on the researchers' market investigation in the field, the price escalation curves of the four types of building materials (brick, cement, steel and aggregate) during the period of field research in China are presented in Figure 1, Figure 2, Figure 3, and Figure 4. Although the fall of steel price to some degree eased the tension of steel supply in the earthquake-affected areas, the quantity of the reconstruction demand was, however, sufficient to play a dominant role in posing difficulty to reconstruction practitioners in procurement of steel products. Our research result, however, is in line with a predication of material shortages conducted by the Sichuan local government, as shown in Table 3 in which lack of materials such as cement, brick and steel was estimated to have a negative impact on reconstruction progress during the three year reconstruction period. Furthermore, the interviewed contractor representatives also reported the labour sourcing difficulty they encountered when participating in the reconstruction work following the earthquake. As an interviewed project manager from a large State-owned construction company mentioned that:

'The rebuilding tasks were incommensurate in scale with the available construction labour in the earthquake impacted areas. This led to a precipitous wage increase of local labour, undermining the sustainability of local construction market' (C4).

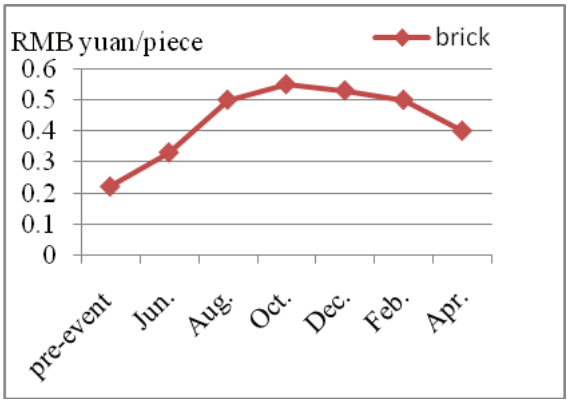

Figure 1. Brick price trend

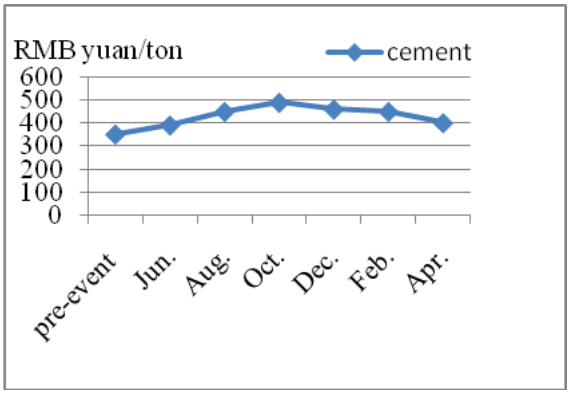

Figure 2. Cement price trend

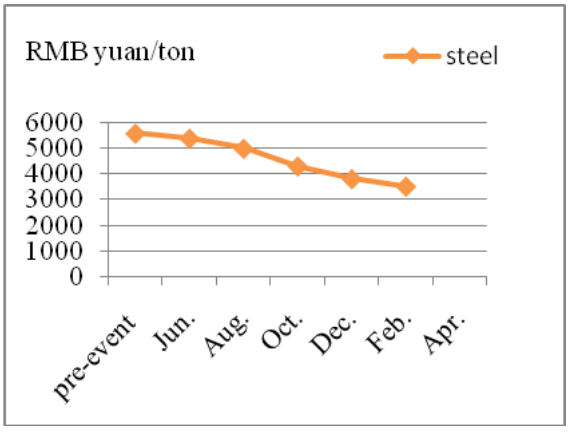

Figure 3. Steel price trend

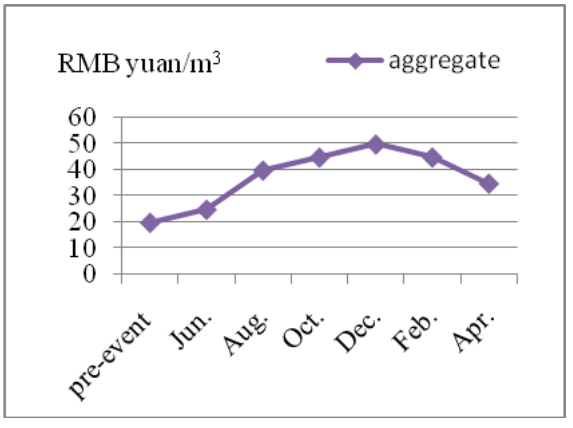

Figure 4. Aggregate price trend

Table 3. Supply shortfalls of cement, brick and steel in earthquake-stricken areas

Items	2008–2009	2009–2010	2010–2011
Cement (million tons)	53	39	31
Brick (billion pieces)	35.5	17.8	3
Steel (million tons)	3–3.6	3–3.6	3–3.6

Source: http://www.sc.gov.cn/zwgk/gggs/jm/

4.2. Current practice to ease resource strains

As was learned from the interviews with a range of respondents in Table 2, the recovery from the earthquake in the affected areas in China was primarily led by the government. In response to the earthquake and large-scale reconstruction, the Chinese government at varied levels initiated a series of interventions to facilitate recovery. This section presents a summary of the interview results under the second question, with regard to the practices and policies adopted by the Chinese decision makers and practitioners in order to reduce the impacts of resource shortages on housing reconstruction.

4.2.1. Government interventions

Not surprisingly, in a relatively government-dominated economy, post-disaster reconstruction in China was government-driven. Both our interviews and in-field observations have revealed that in an immediate aftermath of the earthquake, Chinese governmental authorities enforced tight yet flexible price control and market regulatory interventions in order to contain construction cost inflation and profiteering. These interventions included a series of temporary price regulations, designating production supply, and assigning inspectors to monitor the selling price. In line with the top priority of reconstruction, there was a specific provision mechanism designed by the municipal local government for rural

residences in the earthquake-hit areas. Furthermore, a cost-monitoring system was set up in a number of manufactories to ensure effective implementation of these temporary price restrictions. China's post-disaster resourcing strategies are consistent with the findings of Hirshleifer (1956) who found that to deal with market disorder, profiteering and inflation, regulatory authorities normally turn to 'hard interventions' by directly interfering in manufacturing, supply and transaction.

With regard to the effectiveness of these market interventions, according to the interviewee G1,

'The temporary price regulations rightly focused on the supply side to directly contain the speculative behaviours in the construction market, limited the growth of price, and prevent all-out inflation in forms of setting maximum rates and profit control over material retailers' (G1).

There was a general concern among the interviewees that these measures appeared to work well in a short term, however, as the interviewee B2 stressed that, they also to a large degree discouraged the 'free trade' in the market but encouraged the potential corruption in the public service. This result concurs with the point raised by McGee (2008, p. 551), who claimed that any sort of price controls will cause resources to be allocated inefficiently and could only serve to delay disaster relief.

4.2.2. Increasing production facilities

Apart from the 'hard' regulations, one of the positive actions from the Chinese government was to encourage rapid restoration and investment of local businesses associated with material manufacturing and production by granting fiscal preferential supports such as tax deduction and monetary subsidies. According to the interviewees G2 and G3, there were 75 cement production lines, 760 brick factories and 2 large-scale steel manufactories which were newly approved by the authorities concerned and under construction in Sichuan Province in order to meet the three-year reconstruction demands.

The interviewed official G1 from the local government also stressed a fact that the transparent supply-demand information platform was established in the Sichuan Provincial Government embracing a variety of databases such as demand quantities on construction materials, directories of 95 cement and steel production companies in neighbouring provinces, detailed daily prices of steel, cement and brick in 51 affected counties. As was learned from the interviewee G4, government provided subsidies in support of material transportation and exempted highway tolls for the vehicles which deliver materials to reconstruction areas[5]. RMB $0.1 billion of financial subsidies was assigned to the corporations tasked with material production and delivery to the government-designated areas.

The past practice during the 2004 Indian Ocean tsunami recovery and reconstruction has shown that in Indonesia, in contrast, without the substantial government incentives for recovery of manufacturing businesses such as factories to produce cement (Asian Development Bank, 2007), and brick (UNDP, 2006) and workshop and mills for processing timber (Boen, 2006), the supply capacity of these major construction materials was unable to meet massive housing rebuilding needs, causing project delays. In this regard, the responsiveness of the Chinese decision makers to business recovery of key production materials had, to a great extent, expedited the physical recovery from the earthquake.

[5] By the end of November 2008, the exempted highway tolls in Sichuan Province reached RMB $0.18 billion.

4.2.3. Advocating new building materials

An alternative governmental action for enhancing resource availability for housing reconstruction was to encourage the development of environment-friendly, energy saving and seismic-resistant materials by providing relevant preferential policies for the research institutes and industry associations. According to the interviewees R1 and R2, a variety of building innovations in terms of building materials and techniques had been proposed into the use of housing rebuilding after the earthquake. For instance, the research team of building technology from one of the local involved universities recommended wooden structure replace the conventional brick masonry structure. Some sample wooden houses were built up in the affected villages to strengthen the local people's knowledge of seismic-resistant construction technology and materials. Furthermore, local government attempted to formulate policies to recycle construction wastes produced by the earthquake in a combination of government providing land, enterprise investment and market-oriented operation.

However, alterations of building materials were not widely accepted by the affected populations in China. Only a number of architectural changes to rebuilt houses were seen by the researchers in the field. Our observation is consistent with a common problem proposed by Schilderman (2004) and Boen and Jigyasu (2005) in their examining of structural disaster mitigations in the affected countries. It can be concluded that the lack of understanding of new types of construction materials, however, prevented their wide use and application in earthquake affected areas. Post-disaster reconstruction provides a 'window of opportunity' for integrating disaster mitigation solutions into localized housing culture. This could only be effective when public perceptions and acceptance of safe buildings are improved by fundamental education and knowledge dissemination both before and after an event.

4.2.4. Expanding transportation network

Another contributing governmental action, as was identified during the interviews was to enhance accessibility of available building materials and machinery by systematically prioritising transportation networks across the country. During our reconnaissance trip to one of the worst affected township Mianzhu, we had witnessed all kinds of transport for delivering building materials to the construction sites, including manual and animal carrying methods. The Wenchuan earthquake of such a large scale, according to the interviewed transport planner G4, highlighted the vulnerability infrastructure utilities in disaster prone areas in China. Accessing resources within the constraints of a deteriorated roading network and with limited transport options were proposed by the survey participants as being a key factor that would inflame the difficulties of procurement of raw materials, labour and machine. Some studies looking into post-disaster reconstruction logistics have manifested that high cost of resource transportation (Limoncu and Celebioglu, 2006), and lack of access alternatives (Singh, 2007) are a major concern for overall reconstruction.

In the case of post-Wenchuan earthquake housing reconstruction, as was introduced by the interviewee G2 that, the Transport Ministry of China had approved four river-land joint routes, as shown in Figure 5, for large cargo delivery by fully capitalizing on the comprehensive transport system nationwide. For instance, one of the four lines was from Shanghai via Chongqing to Chengdu. The recovery and reconstruction resources were shipped from Shanghai to Chongqing through Yangze River and then transferred to the earthquake affected areas through Chongqing-Suining highway (295 kilometers), Chengdu-Chongqing highway (339 kilometres) and Yuling highway (413 kilometers). The use of the waterways, according to G4, is likely to provide an economical alternative for transport of construction materials, plant and equipment.

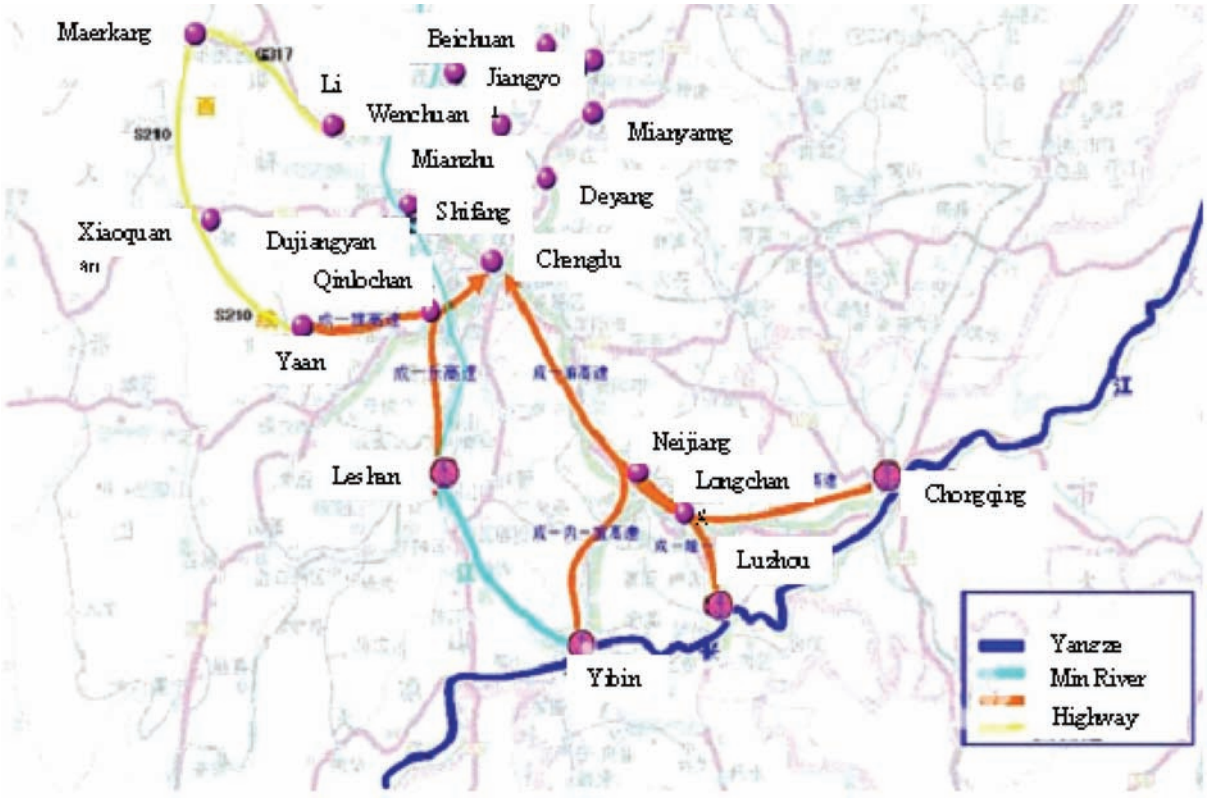

Figure 5. Four river-land joint transport routes after the Wenchuan earthquake
(Source: the Transport Ministry of China, adapted from http://www.moc.gov.cn/zhuantizhuanlan/qita/kangzhenjiuzai/)

These *ad hoc* transport capacity extending strategies for reconstruction to some degree eased the transportation pressure after the quake, however, according to interviewee G4, caused some potential transportation conflict between the normal delivery activities and reconstruction needs and added difficulty to the overall logistics coordination. In addition, mountainous terrain and topology of the affected areas in Sichuan Province means that transporting human resources into the quake zone and for the purpose of transportation of bulk resources, such as plant, labour, equipment and materials into the disaster area remained a major challenge.

4.3. Resourcing constraints in post-earthquake reconstruction

In this research, we asked interviewees to indicate the significant impediments to the process of acquiring reconstruction resources in the aftermath of Wenchuan earthquake. The main constraints identified are discussed below. Such a discussion would further reveal the root causes of resourcing problems inherent in a post-disaster context and issues in the current reconstruction practice in China.

4.3.1. Reconstruction time and speed

The duration and pace set by the Central and local government in the earthquake affected areas was commonly proposed as one

of the most significant factor that affected post-disaster resource availability. Most interviewees pointed out that the imperative to complete rural residence reconstruction by the traditional Chinese New Year in 2009, to some extent, intensified the strain on key material supply. As was learned from the interviewee G3 and a few earthquake victims during our field trip, some of local governments turned to monetary incentives to encourage local affected to commence rebuilding their homes before one year quake anniversary. Belassi and Tukel (1996) proved that the urgency of a project plays an important role in post-disaster reconstruction. Government's expectation, however, in this case, concurs with the local aspiration to rebuilding homes and livelihoods in a rapid manner. However, lessons learned from the past recovery practice such as in New Orleans after the 2005 Hurricane Katrina (Olshansky, 2006; Scharfenaker, 2006; Green et al., 2007), and in Indonesia and Sri Lanka after the 2004 Indian Ocean tsunami (Jayasuriya and McCawley, 2008; Jha et al., 2010) highlighted an important dilemma of reconstruction speed and deliberation that would confront decision makers after a disaster.

Our observations in China, along with past recovery experience in tsunami impacted Indonesia (e.g. Dercon, 2007; Steinberg, 2007; Kennedy et al., 2008) revealed that rebuilding quickly and randomly would impose massive long term costs and risks on the affected communities without a consideration of local resource availability and capacity. However, as Burby (2006) suggested that it is leadership that sets pace and nature of recovery. Therefore, to address the potential of resource shortages after a disaster and competition for limited resources during the reconstruction, it requires priority-based assessment of local resources and needs before reconstruction work starts. Proactive inclusive resource planning, in line with prioritised recovery speed, can facilitate recovery to avoid recreating resource-related vulnerabilities.

4.3.2. Impacts of the economic crisis

The global economic crisis in 2008 was identified by the interviewees as being a less insidious, yet equally destructive calamity to China's construction market, with a great impact on the steel and cement industry in particular. This impact had, without a doubt, compounded the resourcing issues in the earthquake affected areas in China. According to China Iron and Steel Association (2009), in the second half of 2008, steel producers in China were cutting their production and dropping prices of steel. Nevertheless, the interviewees B1, B2, B3 and B4 from the material retailing businesses claimed that to deal with their overcapacity of production, most manufacturers in the steel industry were likely to reserve their products in inventories and reluctant to provide supplies to the earthquake demanding areas at a lower price.

However, in contrast, as examined by Jayasuriya and McCawley (2008) in the 2004 tsunami impacted countries of Indonesia, Sri Lanka and Thailand, the influence of the 1997 financial crisis still played a part in post-disaster reconstruction, particularly on its construction industry. They demonstrated that, unlike Indonesia, Thailand had not suffered from resourcing bottlenecks during the reconstruction after the 2004 Indian Ocean tsunami because of its particular economic circumstances. The higher rebuilding demand in tsunami-impacted areas in Thailand came in the context of a depressed construction sector which had not fully recovered from the 1997 economic crisis and so failed to cause price escalation post tsunami. Therefore, an inclusive recovery and reconstruction plan has to take external economic elements into account. Strategic partnership between decision makers and industry associations is needed to engage those business units

and economic sectors associated with rebuilding and facilitate longer-term commitment of professionals and services to rebuilding process.

4.3.3. Inadequate transportation capacity

The constant disruption of transport systems by a large number of aftershocks and secondary hazards was identified during our research interviews as being a significant impediment to disaster recovery resource procurement. The transport planner G4 revealed that the highway and railway systems in Sichuan Province were mainly damaged and interrupted by a large number of secondary hazards induced by the earthquake and aftershocks, such as landslides, landslips, mud-rock flow and 'quake lakes'. Reopening access was a slow process due to the local particular mountainous terrain topology. Some contractor interviewees (C2, C6 and C9) mainly attributed their difficulty in procuring required resources from outside the rebuilding area for housing projects to the lack of transport access during the recovery and reconstruction period.

Both Chang et al. (2007) and Gagnon et al. (2008) have shown the necessity of a scenario planning approach for the post-disaster logistics preparation. A number of interview participants suggested that transportation of resources be prioritised according to its immediate requirements. A variety of planning policies and programs can help create a more resilient transport system (Litman, 2006). As identified by the interviewee G4 from the transport authority, in the case of post-Wenchuan earthquake roading system restoration, the elemental cost associated with transportation of physical resources is likely to rise since more significant risks in the earthquake zone involves greater impact on the final cost of reconstruction. A thorough review and replanning of existing logistic network is needed, for instance, transporting earth moving equipment at the beginning of the recovery period should take precedence over aggregates. This will eliminate storage and logistics difficulties, while providing the opportunity of allowing the rail to recover which widens the alternatives of effectively getting physical resources intra-regionally.

4.3.4. Dysfunction of the construction market

In spite of a series of material price control policies and regulations in place, construction market disorder and dysfunction, during the reconstruction time when we visited, remained a major concern for a number of interviewees. According to the interviewee G1':

'The superficial ease of inflationary tension in the short term would make authorities underestimate the disaster-economic impacts without a careful assessment of community needs, and in the long run, the construction market would still fall off track, the problem of availability of materials and labour would also persist' (G1).

In most cases of post-disaster reconstruction, resources were supplemented either, by the construction of a large number of new production facilities (Zuo et al., 2009) or, by the reallocation of resources from existing uses to reconstruction projects (Freeman, 2004).

The on-going activities of housing reconstruction in China, as was observed by the researchers, showed a restricted market mechanism for balancing reconstruction demand and supply. This seems analogous to a protocol of government-oriented resourcing during the post-Darwin cyclone in Australia. According to Walker (1995), by setting up a construction 'supremo', the Australia government initiated restrictions on building projects in order to control resource prices. However, post-cyclone inflation was about 75% and this impact even extended to Townsville (Walker and Minor, 1979). In contrast, the 1989 Newcastle earthquake in Australia was different because the

government only controlled building standards and thus, post-disaster inflation rose to about 20% (Shephard et al., 1997). Effective post-disaster reconstruction relies on efficient market planning for an ensured resource supply. The policy interventions should fully activate and enhance the functions of the construction market rather than constrain or substitute the main role of the construction market.

4.3.5. Insufficient engagement of the construction industry

Although the reconstruction work was mainly implemented by the industry practitioners, our interviews identified that the construction industry in China has not been sufficiently involved in the earthquake planning and management. According to the interviewee G1, there exists a misconception in public that the government is the most significant institution the nation could utilize for dealing with disasters. Our on-site observations also confirmed this point. In spite of resourcing facilitation efforts made by the Chinese government, the local contractors and reconstruction organizations in the earthquake-affected areas appeared to be less proactive in reconstruction resource procurement. However, this result is consistent post-disaster situations in other examined countries such as UK (Bosher et al., 2007), and Indonesia (Dercon, 2006). These studies pointed out that except for a few large national construction businesses which had resourcing contingency plans in place, there were no schemes and strategies regarding post-disaster reconstruction, and the awareness of engagement into disaster management was poor.

Furthermore, according to a number of contractors interviewed, for the majority of materials purchased, the planning of deliveries was undertaken on an *ad hoc* basis rather than through a systematic thinking. This led to a prolonged lead time of procurement and the final delay of the rebuilding projects. The interviewee C1 and C4 commented that some materials like cement could not be delivered to the construction site consistently, resulted in interruptions of the work, and the unfinished piles had to be demolished and remould. Similarly, in the tsunami impacted Indonesia, the inadequate resourcing capability of the local construction industry caused frustrations to the implementing aid agencies when participating in housing reconstruction programmes (Steinberg, 2007; Chang et al., 2010).

Therefore, a well-conceived resourcing plan for a possible rebuilding project in a disaster stricken environment means that the contracting organization is aware and prepared for the resourcing issues arising in a recovery process. Cooperative procurement methods and partnerships are also crucial for providing a basis for designing appropriate resourcing strategies based on variations in organizational capacity and experience. It is also important that the government construction authorities, in conjunction with the related sectors devise a variety of motivation, education, training and assistance programs and mechanisms in order for raising awareness in the industry to cope with future disasters.

5. CONCLUSIONS

Post-disaster housing rebuilding priorities require special attention to the implications of resource availability for reconstruction and to underlying resourcing bottlenecks in the reconstruction process. This paper looks into the post-disaster resourcing issue by drawing on a contemporary reconstruction case study after China's 2008 Wenchuan earthquake. Based on in-field surveys capturing perceptions and insights of those participating in post-Wenchuan earthquake reconstruction, this study presents a comprehensive view of resourcing issues and challenges that confronted decision makers and practitioners during the post-earthquake reconstruction period.

Our research findings show that after the Wenchuan earthquake, shortages of labour force and construction materials such as brick, cement, steel and aggregate in the quake affected areas greatly imposed varied tensions on the local market and housing recovery. In spite of a series of government interventions, procurement for these resources was mainly constraint by emerging issues such as (1) reconstruction schedule and speed, (2) the impacts of the 2008 global financial crisis, (3) inadequate local transportation capacity, (4) dysfunction of the construction market, and (5) insufficient engagement of local construction industry. As this research has tried to demonstrate, the factors that affect resource availability after a disaster come both from local reconstruction capacity and also from socio-economic systems in a broader recovery context. Resourcing for construction projects in a post-disaster situation, therefore, cannot be classified as simply a procurement service provided by the construction industry. It should be integrated into a holistic resource planning and preparedness framework for disaster reconstruction.

Such an integration must also recognize the need for decision makers at higher levels and project planner and management involved to give a due cognisance to the real rebuilding needs and local capacity of material production in the earthquake-hit areas, based on which the recovery and reconstruction of different sectors can be better mapped and prioritised. The discussion in the paper also illustrated that to address the five resourcing impediments, different resourcing efforts for housing reconstruction are needed with an emphasis on enabling technical and institutional support from, not only the government, but also from the other stakeholders involved and the construction industry, in particular. The observations incorporated into this paper demonstrated that in order to improve resource management under a government-oriented market, the policies and programs developed in the current Wenchuan earthquake will need to be reviewed and revised to align available resources with local needs.

While grounded within empirical studies in disaster management and resource procurement, this research applies practical insights from the field of project management to examine resource availability during post-disaster housing recovery. The research findings challenge the current paradigm in construction management literature, suggesting that a complex and dynamic disaster environment dictates capacity building in the construction sector, infrastructure strengthening and closer communication and collaboration between involved stakeholders. The study expects to warrant attention from both the recovery planners and construction practitioners and to contribute to future public policy debates on resourcing post-disaster reconstruction, in China, and beyond. Future research focus can be placed on successful resourcing practice in differing recovery contexts. The related operative measures and coordination initiatives for addressing the identified issues in this research are also critical for future research.

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SANTRAUKA

IŠTEKLIŲ TRŪKUMO AIŠKINIMAS KINIJOJE PO WENCHUAN ŽEMĖS DREBĖJIMO VYKDANT ATSTATYMĄ

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Atstatant po nelaimių tikėtina, kad truks išteklių ir kartais nutruks tiekimas. 2008 m. gegužės 12 d. Kiniją supurtęs niokojantis Wenchuan žemės drebėjimas – būdingas pavyzdys. Po katastrofos kilusi išteklių problema, kaip antai pakilusios kainos ir padidėjusi rinka, Kinijos politikams ir atstatymo komandai tapo rimtu iššūkiu. Remiantis praktiniais tyrimais, darbe mėginama išnagrinėti atstatymo veiklą po Wenchuan žemės drebėjimo ir nustatyti sunkiausiai gaunamus išteklius kartu su atstatymo procesui būdingomis kliūtimis jų gauti. Tyrimo išvados rodo, kad ankstyvajame atstatymo darbų etape labiausiai reikėjo, bet daugiausiai trūko tokių išteklių, kaip darbo jėga ir medžiagos: plytos, cementas, plienas ir užpildai. Šių išteklių įsigyti labiausiai trukdė (1) atstatymo darbų tvarkaraštis ir sparta, (2) 2008 metų pasaulinės finansų krizės poveikis, (3) nepakankamas vietinio transporto našumas, (4) sutrikusi statybų rinka ir (5) nepakankamas vietinės statybų pramonės dalyvavimas. Nors po žemės drebėjimo Kinijos valdžios pasirinktos priemonės ir intervencijos būdai lyg ir leido trumpam pašalinti išteklių trūkumus, šių penkių punktų poveikiui mažinti reikia įvairių pastangų, kad spartus atsigavimas ir atstatymas po nelaimių būtų ilgalaikis.