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Learning from Lisbon: Contemporary Cities in the Aftermath of Natural Disasters

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Additional information is available at the end of the chapter

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1. Introduction

Cities survive earthquakes and rebuild with improved urban strategies, architectural designs and building technologies. This chapter will present a detailed analysis of the response, recovery, planning and rebuilding processes after the Lisbon earthquake and compare them to the recent events in Christchurch, New Zealand. Archival research from libraries and museums in Portugal will inform the historical analysis, and interviews and official documents from New Zealand relief and reconstruction agencies will underpin the contemporary analysis. The study aims to identify opportunities and challenges in facilitating good urban design in the process of recovering from a natural disaster, using case studies which are separated by over 250 years, but which both attest to the centrality of urban design in the reconstruction process.

2. Lisbon 1755

This section will look at the Lisbon earthquake and its aftermath, with a view to understanding how design, leadership and governance processes contributed to the production of an 18th century, state-of-the-art urban quarter in the wake of a national tragedy. Particular attention will be paid to the coincidence of enlightened political, economic and technical skills which were judiciously applied to the re-planning of the city. By many counts the thinking was modern, and bears a worthwhile comparison to the recent seismic events in Christchurch, which will be the subject of the second part of the chapter.

3. The event

An estimated 8.4 magnitude earthquake in Lisbon on the morning of All Saints' Day in 1755 reverberated throughout the Iberian Peninsula, Madeira, the Azores, and North Africa. Tsunamis affected the Caribbean and the Atlantic coasts of Europe [1]. Of a population of 250,000, up to 20,000 people perished in the quake, tsunami and fires that followed [2]:

At this moment the earth shook, the sea rose up foaming in the harbour and dashed to pieces the ships lying at anchor. The streets and squares were filled with whirling masses of flame and cinders. The houses collapsed the roofs crashing down on shattered foundations. Thirty thousand inhabitants were crushed beneath the ruins [3]

Aid came from Portugal's colonies and her allies and trading partners England, Germany and Holland. Strategically, local merchants donated a 4% surcharge on imports to the relief effort which gave them critical political influence in determining new land uses for the reconstruction [4].



Figure 1. Panoramas of Lisbon before the 1755 earthquake [various authors] Museu da Cidade de Lisboa

4. Recovery: A vision of economic and political reform

The man in charge of the reconstruction effort, the Minister of State (1756-1777), Sebastião José de Carvalho e Melo, was decisive and commanding in his response to the disaster, relief and the forward planning of the city and his leadership in the crisis cemented his political power over his adversaries until the death of his supporter King José I in 1777. The King would make him the Marquis of Pombal 15 years after the earthquake in recognition of his

leadership during the crisis. In a swift and articulate response to the emergency, the city was immediately surveyed and new construction was prohibited. Looters were publicly hung and able-bodied deserters were prevented from leaving the city and pressed into relief work by the army. Monasteries and public squares were filled with the homeless, and tent cities occupied by merchants and nobles sprouted (King José I and his family occupied an extensive tent and pavilion court in the hills of Ajúda at the edge of Lisbon for some months after the earthquake). Pombal moved about the city directing the recovery operation from his mobile headquarters a carriage which he had commandeered from the royal family.

What followed in the next two years was the ruthless and all-encompassing implementation of a radical plan which would change the political landscape and dramatically improve Portugal's economic position in Europe. The Terreiro do Paço (Figure 1) or Palace Square, had evolved as an elongated, spatially contained, urban space at the edge of the Tagus River in association with the Ribeiro Palace. In the wake of the earthquake the space was reconfigured, along with the adjacent central Baixa district, as the Praça do Comércio, a formal axial square surrounded by monumental public edifices where the business of an empire could be effectively conducted.

Pombal's previous roles as political envoy to London and Vienna and Minister of Foreign Affairs and War (1750-1756), where he oversaw town planting in Brazil, had seen him develop sophisticated ideas on mercantilist economic reform and coherent town planning. In the reconstruction of Lisbon's heart he found the perfect vehicle for both. The aim was to create a modern political centre where commerce could thrive. He had, in his ministerial role, overseen the dismantling of the Portuguese inquisition, the secularisation of education, and the nationalisation of industry [5]. He therefore favoured an institutional shift away from the old nobility (whom he considered corrupt and impractical) and the Jesuits, to the city's commercial elites who had helped finance the reconstruction. A strategically timed and implemented legal re-configuration of property ownership in the Baixa, transferred land from the aristocracy and ecclesiastic authorities to emerging merchant elites, whose collective economic enterprise would eventually succeed in rebuilding Portugal's indigenous economy. The waterfront square was edged with public buildings, which encompassed business, city government, and customs and exchange, in an effort to stimulate local trade and industry, and reverse high local unemployment levels and the traditional dominance of foreign merchants.

Urban renewal in the aftermath of the earthquake was appropriate for other reasons. Portugal had entered an era of nation-building with the consolidation of her borders in the 13th and 14th centuries. By the 16th century, Lisbon's image and role as the capital of a nation and a vast empire stretching from Angola to Macau was considered important, and urban embellishment was funded by gold and diamonds from Brazil. During the reign of King João V significant new urban projects were planned in the west of the city to boost the capital's status. The Águas Livres Aquaduct in 1728 is the best example of a new project that combined the provision of infrastructure with urban-scaled monumentality. Other projects included the construction of the vast and extravagant convent-palace at Mafra, the interior embellish-

ment of 65 medieval and baroque churches and the building of dozens of new places of worship in the neoclassical style.

More significantly, Enlightenment-thinking from Northern Europe opened up the possibility of a scientific explanation for disaster rather than a religious one, rendering reconstruction a rational rather than a superstitious exercise, while the destruction of a splendid European court generated political uncertainties and revolutionary possibilities. As part of the reconstruction exercise, Pombal surveyed the populace in search of technical and scientific data about the earthquake, and his findings pointed to new methods in construction. Liquefaction had been observed in the riverside areas, so new buildings there were constructed on timber piles driven into the soil to act as anti-seismic stabilisers. Timber buildings had survived the quake better than masonry buildings, so new buildings had internal seismic frames added to their fabric. The new streets were widened so that even if the buildings on both sides had collapsed, there would remain an evacuation passage between them [6].

Ana Araújo [7] suggests that the press of the time stimulated a pan-European debate about issues of pragmatic responsiveness to natural disasters and unity of action across national borders. It was certainly the first example of a truly international relief effort after a calamity of such magnitude. Fact and fiction merged in the minds of the populace, fuelled by exaggerated emotive accounts of the catastrophe printed in cheap popular news pamphlets [8]. These served to fuel superstitious terrors, displays of religious fanaticism and dire predictions associated with natural phenomena such as Halley's Comet which was expected to appear in 1757 or 1758. The *auto da fé*, (act of faith, or public burning of heretics) held in the Terreiro in June 1756 was devised as a collective atonement for the earthquake of the previous year [9].

The event also presented political opportunity for the Minister of State to distribute anti-Jesuit propaganda in the capitals of Europe via anonymously authored opinion pieces in major newspapers [10]. Pombal co-opted some of the most influential men of the day in literature and science [11] to disseminate news and views about earthquake recovery, the necessity of repressive civil protection measures adopted post-disaster, and public health and welfare interventions. In the interests of civil obedience, state terror replaced the religious fear of the past.

5. Experience and expertise

The group charged with the recovery and rebuilding of Lisbon were an elite cohort of military engineers whose routine duties involved cartography, architecture and town planning, including the design and construction of infrastructure, (roads, aqueducts, ports, defence structures and fortifications) and associated buildings. They were a geographically mobile and flexible group of men, deployed in situations ranging from the frontier towns at outer reaches of the global Portuguese empire, to its busy cosmopolitan centre of trade and commerce. Their expertise embodied a high level of practical knowledge gained from work in

the field as well as state of the art scientific knowledge. Their training via an apprenticeship system at the University Coimbra, represented a productive intersection of the knowledge embodied in foreign treatises such as those of Alberti and Vitruvius, and the real world they encountered in their active service.

Their approach to the built environment appears to privilege the site-specific adaptation of useful typologies, while giving a high priority to public space and infrastructure (especially port infrastructure, given that so many of the Portuguese colonial settlements and *feitórias* (trading posts) were coastal)[12]. Their sensitivity to the scale differential between the city and the building via a unified architectural language is a notable aspect of the Lisbon plan. Many of the best military personnel were in Lisbon at the time of the earthquake, and others joined them for the special mission of rebuilding the capital. Their designs were infused with the utopianism of the Portuguese school of the rational and civic-minded town planning demonstrated in new world cities such as Goa, Rio, Macapà and Luanda [13].

In 1910, cavalry officer Christovam Sepúlveda published *Manuel da Maya e os Engenheiros Militares Portugêses no Terromoto de 1755* (Manuel da Maya and the Portuguese Military Engineers in the 1755 Earthquake) [14] which identified Maia's central role as the strategist in the planning and rebuilding exercise. Jacôme Ratton [15] identifies military architect Eugénio dos Santos as the person who formulated the principles of the reconstruction.

Sepúlveda highlights two important aspects of the organisational culture of the military engineers. The first was their adherence to hierarchy, discipline and teamwork in military operations and the second was the heavy investment they made in strategic planning. Maia's role in executing both these practices is evident in the terms of reference for the reconstruction that were which embodied in the *Dissertação* and other critical supporting official documents published in the late 1750s. Manuel da Maia's 1755 *Dissertação* [16] describes the strategic solution for the rebuilding of Lisbon after the 1755 disaster. In addition to emphasising leadership, Sepúlveda deemed the teamwork, training and field experience of this group of elite military engineers in the colonial realm as essential preparation for the task.

There was ample regional and local precedent for disaster recovery as earthquakes had plagued Lisbon since its founding. A seismic event on the 26th of January 1531 had struck the city with equal force, but produced a far less acute political reaction due to the relative social stability at the time [17]. The Portuguese had certainly benefited from the study of other disasters such as the 1666 fire of London and the numerous volcanic events of in Sicily, particularly those affecting the city of Catania. Maia had been involved for many years in surveying and engineering projects around Lisbon, and this formed the basis of his knowledge to reconstruct the city. Critically he had been involved in the surveying and building of the Main Fortification Line in 1716, the Águas Livres Aquaduct, between 1720 and 1730, and the Santa Isabel survey in the 1740s. This deep knowledge of the terrain subsequently allowed him to swiftly prepare the alternative plans. He authored the *Dissertação* which described the methods and processes leading up to the publication of the 1756 plan (Figure 2).

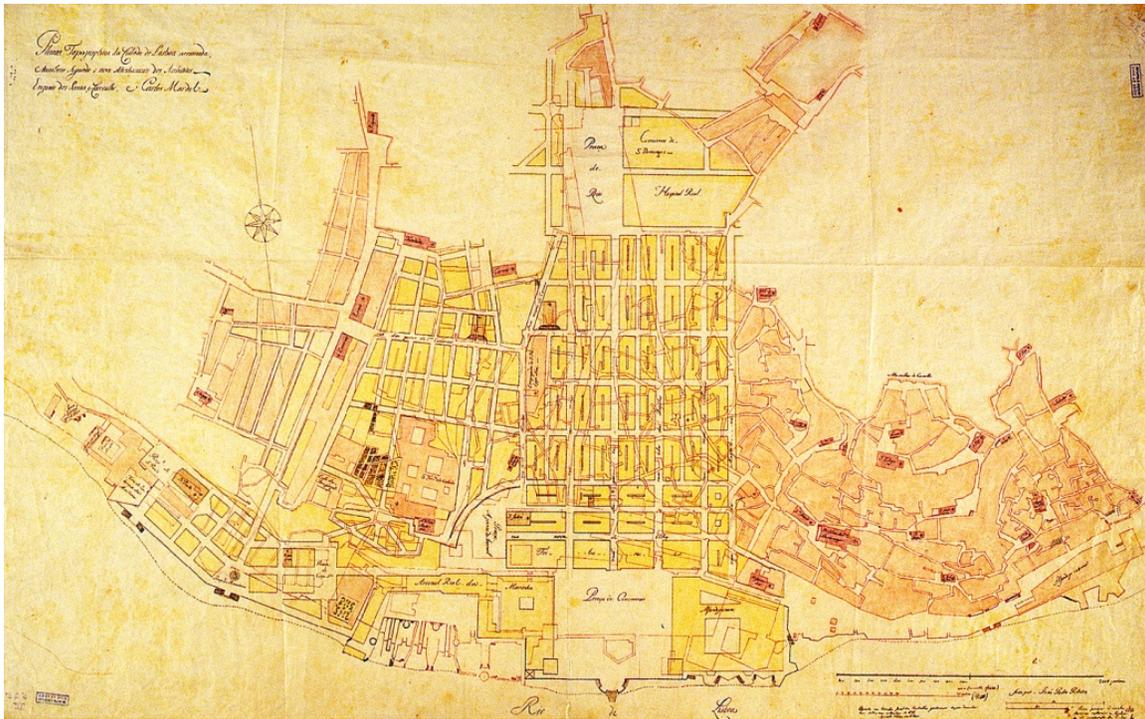


Figure 2. A Topographical Plan of the city of Lisbon [Carvalho and Mardel] 1755 Museu da Cidade de Lisboa

6. Planning: The dissertação

The town planning principles for rebuilding Lisbon were established within 5 months of the event, in Part I of the *Dissertação*, which directed that options for both rebuilding and relocating the city be considered. There was an impetus to rebuild and relocate the court in a better place (either at Bélem or São João dos Bem-Casados) which opened up the possibility for locating new public buildings in the Baixa. Layouts were subsequently developed by military architects Eugénio dos Santos and Carlos Mardel.

Part II of the *Dissertação* was comprised of a legal decree in May 1756 that governed land ownership, construction and finance for the rebuilding of the devastated centre, and a set of development rules for areas of expansion at the periphery. Part III of the *Dissertação* was comprised of the alternative plans, which covered a range of rebuilding and relocation options. Maia presented six options investigating variations of street widening, ground re-leveling, adjusted building heights, all contributed to a radical new block morphology, residential-building typology (with trade and craft premises at ground level) and sense of urban scale [18]. A prefabricated, technically innovative and stylistically simplified four-

storey building type was developed. This building ingeniously incorporated fire walls that extended above the roof line and earthquake resistant diagonally braced, timber load-bearing cages called *gaiola* that sat independently within the masonry perimeter walls. Building components were prefabricated on a large scale off-site, allowing speedy on-site assembly with minimal traditional craft involvement [19].

The plan ultimately chosen, incorporated the following mechanisms and characteristics which are documented by Claudio Montiero [20]:

1. A standardised building type
2. A standardised construction solution incorporating fire separations and seismic frames
3. A rational and generous public space network based on pre-existing places
4. The use of the rubble from the ruins to raise and regularise the levels of the Baixa by 1.2 metres, and reclaim new land from the Tagus
5. A disregard of property ownership boundaries (especially the location of churches) so as not to compromise the rigorous geometry of the new plan

This formed the basis for the legal provisions of the legal decree of June 1758 which finalised the plan. It had taken two years for the plan and the legal and financial exchanges to align. A year later, in June 1759, re-building finally commenced.

These critical ownership reforms relied on Pombal's public credibility and private influence at Court. The period was dogged by multiple conspiracies, including a palace coup in 1756, and an assassination attempt on the King in 1758. These behind-the-scenes machinations lengthened the plan's implementation time, but unlocked the heart of the city as a centre of trade and commerce, thereby better serving the emerging merchant class and challenging the historic power of nobility and clergy. The plan largely preserved the places and names of the historic city and retained the location, hierarchy and functions of three main squares (with the re-naming occurring later). Churches that had been free-standing were now integrated into the Baixa blocks.

The Praça do Comércio doubled the size of the former Terreiro do Paço, by reclaiming land from the river Tagus. The new square's symmetry, focusing on an equestrian statue (flanked by the animals of Portugal's far-flung continental empires), and the triumphal arch to the main street, Rua Augusta, constituted the axis of the plan as a whole. The post-earthquake square had a statue of King José I at its heart but perimeter uses were designated for functions of state, with the palace itself relocated to the city edge at Ajúda [21]. While symbolically, a royal statue still stood at the centre of Lisbon, functionally it was now a place for commercial enterprise (Figure 3). Blocks were configured in a simple proportional and compositional system that supported elegant and environmentally comfortable street sections and public-space footprints. There was a hierarchy of three main streets, each 60 palms wide, that were named for the guilds (Rua da Prata, Rua do Ouro or Silver and Gold Streets respectively), cross streets that were named for church and parish interests, and North-South streets, each of widths of 40 palms, that were also named for guilds.



Figure 3. Praça do Comércio [Rick Allender] 2007

The streets determined the building fabric. The building heights were to be no higher than the width of the streets and thus set a new standard for access to light and air in an urban building. A system of dividing dwellings by floors, with retail at ground-level and artisans' workshops at basement-level, was developed. The arrangement of three floors of identical apartments plus an attic above the ground-level floor was the origin of modern mixed-family ownership in Portugal, and the typology represented the potential for a mixing of classes in one edifice, each with its own separate entrance. Both shops and apartments were built to be rented, thus facilitating urban housing as a form of property investment.

The plan's implementation was directed by José Monteiro de Carvalho, who materialised the abstract rules for scale and the architectural features of the urban blocks at a large scale, while enforcing technical standards such as fire compartments between tenancies, new sewer locations and the cage structures. He was also attentive to the finer details of serial design elements required for cast-steel balconies, the ashlar masonry trim to building bases and openings, and consistent window and door joinery profiles (Figure 4). Up to this time he had been in charge of demolition, which earned him the nickname Bota-Abaixo or knock-it-down.



Figure 4. century standardised building types in Chiado District [Diane Brand] 2004

This aesthetic and technical system became the basis for re-planning Lisbon as a whole, especially around the new palaces, and in areas developed at higher densities in the western part of the city. The scheme set the tone for a future direction of urbanism in Lisbon that embodied a new rational Cartesian pattern but which was firmly anchored in a traditional morphology. Over time the plan set aesthetic, technical and legal precedents but these were not fully appreciated until the modern era, when separate built environment professional disciplines such as architecture and planning emerged and their histories were fully researched.

7. Rebuilding

Claudio Monteiro [22] suggests that legislative reform enacted during the reconstruction of Lisbon was driven by the plan's necessary transformation of the structure of urban property

ownership, and the careful reconciling of individual rights with the security of future investment. The reconstruction plan and the resultant legislative reform were the tools that brought about eventual political and economic reform. Pombal's aim was to consolidate the power of the King while at the same time modernising the nation's legal, economic and social structures.

The measures used to achieve these included:

1. The surveying of existing buildings at the time of the earthquake to avoid disputes during reconstruction, especially when an overhaul of the land ownership arrangements was contemplated (Wren's plan for London after the fire in 1666 had been frustrated by an inability to rationalise the nobility's ownership of the large estates in central London).
2. A prohibition on constructing or reconstructing buildings before the plan's approval:
 - a. Outside of Lisbon, to stop the city growing randomly and
 - b. Within Lisbon, to prevent the rebuilding of buildings partially destroyed by fire (less than one third of the original buildings were in a habitable condition and no alternative accommodation existed apart from tent cities and timber shacks erected in public spaces).

The plan was approved two and a half years after the earthquake, and the first lots were reconstructed three and a half years later. Nevertheless, illegal urban development had sprung up in spite of harsh enforcement of the decrees.

3. Freezing rents and freezing the price of construction materials, to combat speculation, eviction and exploitation around the shortage of construction materials and rental accommodation. This was done by restricting any new lease agreements to perpetual leases or long-term rental contracts.
4. Creating the conditions for legal, religious and political reform by freely compensating and transferring pre-existing property ownerships into newly agreed formats
5. The complete demolition of the Baixa to make way for a despotic but utopian and progressive plan [23]

8. Compensation

Land within the Baixa was immediately appropriated by the state and re-allocated, with preference given to existing land owners, leaseholders or administrators for nobles, the church or the crown. Compensation was based *only* on site area, and not the post-earthquake building condition. New lots were allocated on the condition that redevelopment would be completed within five years, effectively rendering the exercise a land re-adjustment operation rather than an exercise in eminent domain, while preventing long-term speculation of development leap-frogging.

Undersized lots, oversized lots and lots eliminated by the creation of new public spaces or streets were paid fair land swap or cash compensation in proportion to the frontage width of the site. Cash payments were necessary since there was a greater total area for public space in the new plan and therefore an undersupply of new sites. Maia proposed a proportional reduction of all buildable areas to account for improved amenity as a result of more public space in new areas. The chief surveyor of the inspections, Alexandre José Montanha divided the Baixa into seven zones of value, thus setting up a financial mechanism by which properties were exchanged or compensation calculated with a 'premium payment' embedded for superior sites adjacent to public space.

In this way the plan created value. The overall effect was to replace certain types of landowners (nobles and secular clergy) with merchants, sparking what Subtil called 'political earthquakes' in Portuguese society [24]. The compensation system and plan stimulated investment from the business community who had financed the reconstruction (via credit or purchase). This in effect led to a significant redistribution of wealth, a consolidation of economic power among the middle class, and a new degree of upward social mobility. The move also unlocked the encumbrances and liens strictures embedded in the medieval property codes that had inhibited clean development processes within the city.

Complete execution of the plan took over 40 years. An initial displacement of Lisbon's population to the west immediately after the earthquake inhibited the uptake of property in the centre. The ancient elites also retreated, taking the court sector with them.

9. Authoritarian processes

Authoritarian processes were the key to the effective reconstruction of Lisbon. Pombal was appointed by the King to his position as Minister of State and he used this mandate to centralise political power by removing the Senate from the state decision-making processes and from the implementation of the Baixa plan, thereby breaking a longstanding tradition of local autonomy in planning and taxation matters. The institutional makeup of the reconstruction process evolved as the pragmatics of the situation dictated, with two complementary bodies emerging: The first was the Lisbon Neighbourhoods Inspectorate as the civil defence responder in 12 neighbourhoods city-wide. This agency was also instrumental in clearing debris, removing and burying bodies, executing surveys and re-allocating land. The second was the Public Works Department which was formed to implement the plan, and projects including public spaces and new buildings. The technical team, comprising of army officers in the civil administrative hierarchy, originated at the Lisbon Public Works Draughting Office (*Casa do Risco da Obras Públicas*) which later became the Public Works Department. This reduced, focused and disciplined chain-of-command, facilitated the absolute control required for such sweeping changes to the urban space configuration and the resulting shift in political and economic hegemony.

The first order of business was the creation of the public realm, with new streets, squares and gardens. Public health was foregrounded with upgraded sanitary infrastructure, water supply and transport systems given priority. The construction of essential public buildings for trade and business continuity such as the Customs Building in Praça do Comércio was also critical as they served an influential special-interest group. Reconstruction took roughly until 1807 to complete, ironically coinciding with the royal family's flight to Brazil as Napoleon's troops massed on the border during the Peninsular Wars.

10. Urban design opportunities

A pamphlet at the time of the 1755 disaster optimistically stated that 'Lisbon could not have suffered a more fortunate tragedy', indicating the potential the populace saw in the reconstruction process [25]. A major aspect of this fortune clustered around the implementation of a good example of urban design, one that was ground-breaking for its time and which still ranks as outstanding. The plan proceeded with a new gridded layout for the Baixa quarter, based on the disaster and re-planning precedents of the fires in London and Rennes, and the earthquake in Catania and planning precedents such as the 1620, 1673 and 1714 extensions to Turin [26]. Among precedents for the Baixa Plan were Wren's 1666 plan for London (new street alignments and property subdivision), new Turin (the regularised geometry of public space and city blocks) and the Place Royale, Place Vendôme and the Royal Palace at Bordeaux (the continuous articulated facades, marked entry points and arcaded bases of the buildings which framed the public space) [27]. It represented a successful example of contemporary urban disaster and urban design knowledge of in 18th century Europe.

The Terreiro do Paço was reconstructed and renamed the Praça do Comércio (Figure 5). Rubble from the earthquake was recycled (eliminating the disposal problem) and an area of land equal in size to the original square was reclaimed, extending the urban platform into the Tagus. The reconstruction of Lisbon presented an opportunity to integrate the waterfront square into the urban fabric. The new monumentally scaled square used symmetry and architecture to integrate a complex of buildings embracing the space into the urban fold, and created a powerful central axis penetrating into the city behind via Rua Augusta, thereby linking the square to the Rossio (Lisbon's other principal square) beyond. Pombal's project redressed the problems that had beset the Terreiro as an urban square. Certainly the architectural and urban legibility of the square was enhanced, the buildings were better scaled to city blocks and there was more permeability to the Baixa, with vistas along Rua da Prata, Rua Augusta and Rua do Ouro. However, the authoritarian method of delivery required the subordination of individual property rights to the public interest, with new development and construction precisely defined within the strict constraints of the plan. The effect was also to subordinate architecture to urban design, with exacting and specific controls placed on building envelopes, construction methods, uses, appearance and materials.



Figure 5. Praça do Comércio [Susana Pereira] 2011

The following section discusses urban design initiatives arising from a series of devastating earthquakes in the new world city of Christchurch, New Zealand and compares them to the 18th century event in Portugal. Two years after the earthquakes, urban design strategies to rebuild the broken city have been formulated but are not yet implemented.

11. Christchurch 2010 and 2011

Christchurch was planned in the mid-19th century as the last Wakefield settlement to be established by a private colonization enterprise called the New Zealand Company. The company was involved in the establishment of six urban centres in New Zealand: Wellington [1839] Wanganui [1840], Nelson [1841], New Plymouth [1842], Dunedin [1848] and Christchurch [1850]. The New Zealand Company brought more than 9,000 hopeful settlers to New Zealand up until 1843 [28], with each of the towns achieving numbers of between 1000 and 4000 in the first years of settlement. Christchurch was sponsored by the Church of England and aspired to recreate a stable agrarian, hierarchical society on fertile land, between the Pacific coast and the Southern Alps on terrain purchased from the local Ngai Tahu tribe. A rectangular grid was surveyed onto flat swampy land and adjusted where necessary to accommodate the Avon/Otakaro River, which meandered across the site. The diagram of the city incorporated the grid, the river, two diagonal roads registering the principal transport routes to the port of Lyttelton and the main road north, a cross-shaped central square (where a cathedral was later built), a market adjacent to the Avon River, two asymmetrical peripheral squares, and parklands providing generous and varied public and recreational space. In June 2010 the city was New Zealand's second largest, with a population of 376,700.

12. Events

In the early morning of Sunday the 4th of September 2010 a magnitude 7.1 earthquake located 40 km west of Christchurch on an east-west fault, not previously identified, struck the city. The fortuitous timing of the event explains the lack of fatalities but there was widespread damage to unreinforced masonry (URM) structures [walls and chimneys] in Christchurch and surrounding towns. Nineteenth century URM shop fronts collapsed into main thoroughfares in the CBD, and there was widespread liquefaction to eastern suburbs' resi-

dential areas close to rivers. This earthquake triggered a series of aftershocks that moved progressively closer to the city, culminating in a shallow, 5km deep, M 6.3 earthquake on February 22, 2011 (Figure 6) centred at Lyttelton. This too occurred on an unidentified fault. This second major event resulted in 181 deaths, with more than half of these occurring in the collapse of the Canterbury Television Building. This earthquake caused further significant damage and collapse to URM structures in the CBD, more liquefaction to eastern suburbs' residential areas close to rivers and rock falls and landslides to the south and southeast. The result is that between 50% and 70% of buildings in the CBD are likely to be condemned for demolition with the discovery that many structures are out of vertical axis alignment due to differential settlement and the realization that the repair of others is uneconomic.



Figure 6. A 6.3 magnitude earthquake strikes Christchurch on February 22nd 2011 [Gillian Needham]

The civil defence response was immediate, with international urban search and rescue teams arriving from nations such as Australia and Japan to relieve local emergency services. Emergency response centres were swiftly established in parks, and sports and community buildings, with temporary accommodation provision in the form of tents, caravans, and prefabricated houses deployed by the Department of Housing and Construction. The entire CBD was cordoned off and placed under police and army jurisdiction for an extended period, leaving many businesses without access to their premises. The slow and uneven process of insurance compensation has led to businesses relocating to other centres in New Zealand or locally to the western edge of the city close to the airport. The entertainment centre of the city has re-established itself in the west along Riccarton Road. With more than half of Christchurch's listed heritage buildings (250) located in the CBD, the city's patrimony has been particularly hard hit with more than 100 demolitions to date. The iconic Anglican Cathedral, the Catholic Cathedral of the Blessed Sacrament and the Canterbury Provincial buildings suffered significant damage (Figure 7).



Figure 7. Canterbury provincial buildings post-earthquake [Diane Brand] 2011

13. Recovery

After the second earthquake it was clear that existing central and local government agencies were not equipped to facilitate recovery operations, and The Canterbury Earthquake Recovery Authority (CERA) was formed on March 29, 2011 as a special government agency for the co-ordination of the recovery and rebuilding activities in Canterbury. The Canterbury Earthquake Recovery Act [29] gave unparalleled (in New Zealand terms) authoritarian powers to the Minister of Earthquake Recovery, The Right Honourable Gerry Brownlee, although in practice the powers have been exercised only with the agreement of the cabinet (the government's executive level ministerial group). In particular the CER Act allows a recovery plan approved by the minister to override the requirements of New Zealand planning legislation frameworks embodied in the Resource Management Act, the Conservation and Reserves Acts and large parts of the Local Government Act (although not the funding provisions, and the Land Transport Act).

The government's response to the Canterbury earthquakes occurred in an environment of mistrust between national and local government, characterised by the dissolution of the re-

gional council, Environment Canterbury, in March 2010, and the quite different leadership styles of the mayor and the minister. Part of the reason for the distrust lay in the different underlying political philosophies, with the ruling national government espousing a 'shrinking government' position together with the sales of government assets as a means of reducing the national deficit. In contrast, local government in general, and in particular the Christchurch City Council (CCC) supported maintaining the level of local government services as a minimum, with the CCC pursuing a clear position of holding onto city assets in city-owned holding companies and using these to generate income or reduce tax liabilities.

In 2011, the government introduced an amendment to the Local Government Act aimed specifically at limiting the services local governments could provide and the levels of rate increases they could introduce. The CER Act specifically excluded the minister from making changes to the funding provisions of the Local Government Act and there have been continuing discussions about the allocation of costs between national and local government ranging from the emergency response costs to repair and rebuilding costs. The national government has clearly stated on a number of occasions that it believes that the CCC should sell some of its assets to fund the recovery bill.

The CER Act established a new government agency to oversee the recovery of Canterbury and the government's investment in the rebuilding of Christchurch. The act specifies that the minister can direct the city council, but does not clearly establish the respective roles of the organisations, or create any direct organisational links or lines of management apart from general requirements to consult. The newness of the government agency CERA, coupled with the pre-existing responsibilities of the council, has led to a lack of clarity about their respective roles, with duplication happening at a number of levels between the two organisations.

The CER Act specifically required the CCC to develop a draft recovery plan for the central city in nine months for the minister's approval, including public consultation. Planning for the rest of the Christchurch metropolitan area was the responsibility of CERA. The Draft Central City Plan (CCP)[30] was completed in eight months, however the minister spent a further seven months reviewing it. When the minister received the draft he endorsed the vision contained in the first volume, with the exception of the proposed transport changes, but he set aside the proposed regulations for further investigation [31]. The 'blueprint' plan [32], subsequently approved by the minister, broadly adopted the range of major infrastructure projects proposed in the Draft CCP and retained the majority of the proposed regulations including the reduced height limits. The major changes from the Draft CCP was the removal of the regulations requiring improved environmental performance from buildings (the BASE assessment developed with the NZ Green Building Council), the removal of the financial incentives for rebuilding proposed by the council and the removal of the majority of the transport provisions pending further investigation.

The Canterbury earthquakes resulted in extensive land damage and areas of liquefaction, particularly in the eastern part of the city (Figure 8). The resulting changes in elevation included some areas in the Port Hills rising by up to 500 millimetres while areas around the estuary and Avon River subsided by more than 500 millimetres (Figure 9). In extensive areas

the cost of land remediation, flood protection and/or the restoration of services made it un-economic to rebuild on the terrain. The government assessed all residential land in Christchurch and the surrounding towns based on extensive geotechnical studies and eventually classified them as either 'green' (fit to rebuild) or 'red' (unfit to rebuild). Subsequently, the government has set about purchasing more than 6,000 houses in the residential red zone based on the 2009 rateable valuations. The houses are generally either clustered in low lying areas around the Avon River and Estuary or vulnerable to rock fall in the Port Hills.



Figure 8. Liquefaction in the eastern suburbs of Christchurch (2011) New Zealand Aerial Mapping Ltd for LINZ

The retreat of settlement along the Avon River and Estuary in Christchurch has provided a microcosm of the kinds of issues likely to be faced by many coastal cities worldwide, if sea level rises predicted over the next century occur [33]. The model of strategic retreat, from vulnerable areas may become relevant in many other areas. While the Christchurch model has addressed the issues of strategic retreat and attempted to manage the economic impact on residents, no attempt has been made to address the impacts at a community level. However, a map showing the areas where 'red zoners' have relocated reveals a scattered pattern determined by the prices and availability of houses, rather than any managed attempt to relocate communities.

The CER Act facilitated the immediate use of earthquake rubble for reclamation work to extend the container port at Lyttelton. This would have been difficult and protracted under the RMA. The port is one of the key economic drivers for the Canterbury economy, and the port extension reflects the changing scale and technologies of port logistics. The CER Act has also been used to fast-track residential subdivisions, thereby short circuiting the currently protracted consent and environment court processes. The intention has been to free up residential land so that people who have been displaced by the earthquakes, and workers arriving in Christchurch to assist with the rebuild can be adequately housed. In doing so, the minister has confirmed the overall urban form proposed in the Greater Christchurch Ur-

ban Development Strategy which sets out urban limits, greenfield residential areas and housing densities, targets for intensification, urban design outcomes and key transport corridors (although these measures are currently being challenged through the courts). The need to dispose of a huge quantity of rubble in a very short timeframe, and to expedite the provision of new housing stock to replace that damaged and destroyed are common issues for cities struck by earthquakes. Both Lisbon and Christchurch used authoritarian powers to address these issues in a timely and economically beneficial manner.

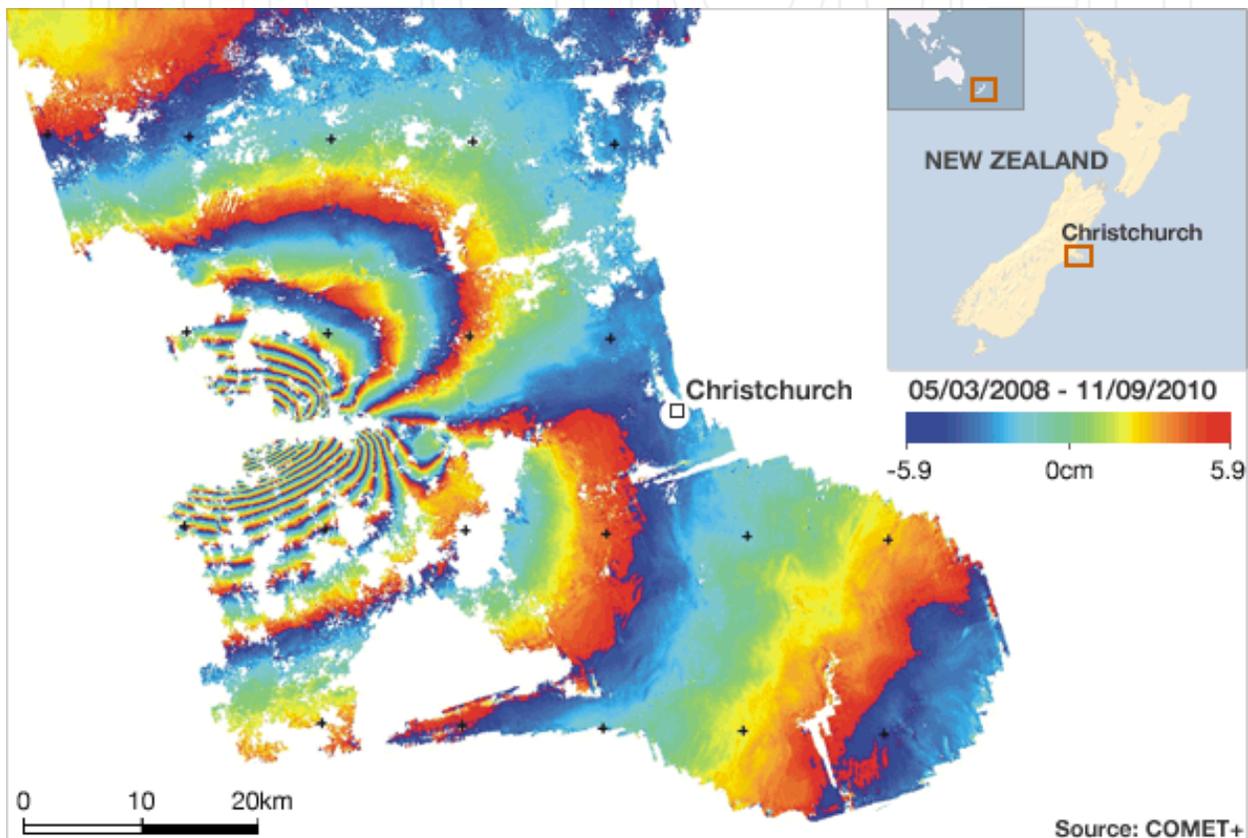


Figure 9. Lidar Map of Christchurch showing ground level changes (2010) COMET

14. Compensation

After a wave of earthquakes that plagued New Zealand between 1929 and 1942 (the worst of which was the M7.8 Hawkes Bay earthquake of 1931 which completely devastated the cities of Napier and Hastings), the Labour Government created the Earthquake and War Damage Commission. The commission eventually insured all residential properties, including the land (up to \$100,000 for buildings and \$20,000 for contents) against damage from natural disasters [34]. Commercial property must be privately insured. In early 2010, the EQC had reserves of NZD 5.6 billion backed by a government guarantee. However the total insurance estimate for the Christchurch earthquakes is up-

wards of NZD 30 billion [35] and represents the worst natural disaster in a developed nation relative to size of economy. Private insurance fared no better, with the market dominated by only 5 principal providers, several of whom have struggled to pay out claims without government assistance. The compensation for damage is an on-going saga of bureaucratic complexity, delays and individual suffering which has been exhaustively documented by the nation's media. Policy neglect had contributed to the underinsurance of the majority of New Zealand homes, with EQC covering a quarter of the average value of a New Zealand home, and maximum premiums still at their 1973 level of NZD 67.50 per annum in spite of advice to increase these in 2008. A premium for land insurance had never been charged, but this type of damage turned out to be the most expensive. While the annual EQC premiums were raised in the immediate aftermath of the earthquakes, policy revision in the insurance sector is still under consideration. Discussions include the introduction of land insurance, better processes of alignment between land use decision making in territorial local authorities and disaster insurance agencies, and the level of future risk-sharing between EQC and private insurers [36].

15. Experience and expertise

Local government manager Warwick Isaac, who was overseeing the demolition of buildings in Christchurch, was appointed to lead the Central Christchurch Development Unit (CCDU) which is tasked with leading the rebuilding of the central city. Dubbed 'the demolition man', a Tom Scott cartoon has him lamenting "If I had known you were going to put me in charge of the rebuild Minister I wouldn't have pulled so much down." Both the council's Draft Central City Plan and the 100-day Blueprint subsequently produced by the CCDU were prepared by multidisciplinary teams led by urban designers. Although the approaches were fundamentally different, with a community-led bottom-up process for the Draft Central City Plan and a technocratic top down 'masterplan' in the Blueprint, both documents were 'design-led' in that they used design as the key method of developing the plans with built environment professionals (urban designers, landscape architects, architects) holding the key leadership roles responsible for developing plan content.

The Draft Central City Plan was developed by a multidisciplinary in-house team of council staff that included seconded team members from national and international consultancies including Gehl Architects from Copenhagen. Hugh Nicholson, the Principal Urban Designer at the Christchurch City Council, was responsible for delivering the content of the plan. The team included urban designers, architects, landscape architects, engineers, economists, planners, community advisers, communication specialists, sustainability advisers and recreation and open space planners.

The 100-day Blueprint was prepared by a consortium of design companies led by Boffa Misckell, a local company specialising in landscape architecture, urban design and landscape planning. The consortium included local architects Warren and Mahoney and Sheppard and

Rout as well as specialist convention centre and stadium designers. The team was led by landscape architects Don Miskell and Rachel De Lambert and urban designer Marc Bailey.

16. Planning

Within three months of the February earthquake, an extensive public consultation exercise was undertaken with the people of Christchurch to help shape the future plan of the devastated city. The website shareanidea.org.nz generated 58,000 hits and engaged the public in four key areas: move (transportation), market (business), space (public place and recreation) and life (mixed uses), across traditional and social media networks. This was followed by an interactive expo, 10 community workshops, 100 stakeholder meetings and a professional competition for 5 selected sites. An unprecedented level of public participation generated 106,000 ideas over six weeks and these informed the development of the Draft Central City Plan.

One of the firm assumptions underlying the Draft Central City Plan was the maintenance of the existing street and land ownership patterns. In part this recognised the strong urban form provided by the existing grid and its heritage values. In part it was in response to initial estimates that suggested 50% of the buildings in the commercial core might be demolished (subsequently this looks to be greater than 60%). This implied that there was still a substantial residual value in the remaining buildings and services which the city could not afford to lose. In terms of broad urban design objectives, both the draft CCP and the Blueprint set out to provide an enhanced network of green open spaces based around the Papa o Otakaro (Avon River Park) and Cathedral Square, to rebuild a more compact intensive low-rise commercial core, to increase the number and density of inner-city residents, and to promote mixed-use developments in areas surrounding the core. The plan also proposed more sustainable transportation systems, including a light-rail system from the university to the CBD, that would eventually connect into a regional rail network and a grid of cycle-ways. The redevelopment clustered around a set of core projects seeded by government, which were designed to attract investment and rebuilding in the CBD and these included a greening of Cathedral Square, a sports hub, a convention centre, a central library and a hospital campus.

One of the more controversial urban design proposals in the Draft CCP was a reduction in height limits to 28 metres or seven stories. Christchurch was the first major Australasian city to propose a low-rise urban form, moving away from the modernist podium and tower model of development. The reasons for this were partly the high level of community support for low-rise buildings and their desire to create a more human-scale environment with better environmental conditions, including improved sunlight access and reduced wind funnelling. Additionally, economic modelling indicated that due to the increased foundation and structural costs required to build higher than six to seven storeys, the most economically viable built-form with the highest rate of financial return was in this height range. The final reason was to address the oversupply of commercial land in the core, by rebuilding a

more consistent intensity of development over the area of the core, avoiding the spikes of oversupply and undersupply provided by the tower model. There was a strong backlash from the business community against the proposed height limits and this was one of the provisions that the national government set aside when it reviewed the Draft CCP. However at the end of the review, they reconfirmed the height limits based primarily on the economic impact assessment and the land supply issues.



Figure 10. The CCUP Blueprint (2012) CCUP

The Draft CCP proposed using built-form restrictions to further promote a compact commercial core, with a higher intensity of development through the use of incentives and by limiting development potential outside the core. The Blueprint adopted a far more interventionist approach by establishing a 'green frame' (reinstating nineteenth century parklands) and compulsorily acquiring large areas of land surrounding the core. The long-term future of the proposed frame is not entirely clear. Some parts of it appear to be intended as permanent open spaces, some parts such as the health precinct are earmarked for campus-style commercial development, while other parts appear to form a potential land bank for release once land in the core has been fully developed.

In summary, the Draft CCP adopted a multifaceted approach to recovery that incorporated a wider range of projects and implementation tools. The vision balanced incentives and regulation to deliver major catalyst and public space projects, alongside sustainability, housing,

arts and transport projects. The blueprint focuses more deliberately on national government priorities, providing a regulated vision embodied in a range of catalyst projects that involve rebuilding critical public and economic infrastructure such as the hospital and the convention centre. At the second anniversary of the first earthquake, the city has started to rebuild with 1000 building consents in the past 12 months. Processes are being put in place by CCUP to fast track significant projects through an urban design board process while the CCC Urban Design Panel is doubling in size to cater for the anticipated increasing volume of resource consent applications.

17. Conclusion

Events in Lisbon and Christchurch stand apart in chronology, severity and extent, recovery management, and design outcome, but have sufficient in common to draw some interesting and relevant conclusions to 21st century disaster-response strategies. Prime amongst these is the use of urban design as a revitalisation mechanism, as it is a natural aspiration to want to rebuild a devastated metropolis anew, correcting the mistakes of the past by implementing new and state-of-the-art practices to envision a better city.

Lisbon suffered not only a cataclysmic earthquake but also a devastating tsunami and fire. Fortunately for Christchurch the latter two stressors were absent, and 250 years of improved planning, seismic and fire engineering performance, reduced the relative death toll from building collapse while generous provision of public space allowed the population to escape to safer areas. Christchurch, in achieving this high level of technical preparedness, is much indebted to Lisbon which pioneered many contemporary post-earthquake response strategies. Two hundred and fifty years before the terms resilience or sustainability entered the built environment lexicon, their guiding principles were applied in Lisbon. Pombal's engineers made the decision to rebuild in the same location, but not before investigating six alternative sites and researching the technical failures that led to the high death toll. In so doing they were embedding in the plan the future sustainability of the city and built in resilience for future seismic events, not only for themselves but also for others who chose to follow their example.

The civil defence emergency response was, for the first time in history, an international one, with Portugal's trading partners stepping in to assist. The necessary revenue for recovery was raised via import taxes levied by local businesses. Exploitative behaviours were curtailed by punishing looters, freezing rents and the price of materials. The immediate surveying and demolition of the area reduced the territory to a uniform and indisputable condition in terms of future claims. Prior to any rebuilding, a post-disaster analysis was conducted to establish which buildings had survived and why. These investigations led to a number of technical innovations that required a new formal and technical building typology. This simple and elegant solution to rebuild the city relied on three crucial pillars: the complete demolition of the devastated Baixa, the re-drawing of property lines, and an urban design plan that integrated these technical provisions into a best-practice vision (based on solid interna-

tional precedent) for a commercial rather than an institutional centre for Lisbon. The implementation of these strategies was only possible due to the authoritarian nature of the governance system at the time, and an emergency response which delivered this power unilaterally into the hands of the Minister of State.

A similar approach is clearly not possible or appropriate in a modern democracy, although the potential exists and was contemplated within the New Zealand legislation introduced to affect recovery plans in Christchurch. The national government has committed substantial leadership resources and legislative support to the recovery of Christchurch and the Canterbury region. Of particular note has been the strategic land use withdrawal from the residential red zone, the on-going demolition of dangerous buildings, and the proposed major infrastructure and facilities as catalyst projects. The authoritarian powers provided through the CER Act have enabled these initiatives to occur with the minimum of delay or inappropriate process, although some delays have occurred due to the lack of clarity about the respective roles of the council and CERA. The Draft CCP proposed an integrated plan for the central city, while the blueprint approved by the minister focuses on rebuilding the major infrastructure and facilities and leaves out much of the 'glue' - the smaller scale projects that hold the big moves together. The absence of urban residential typologies or social housing to accommodate earthquake victims from the list of prioritised projects, overlooks the capacity and necessity of embedding these in the plan as community or capital investment opportunities in the way they were in the Lisbon plan. The council currently intends to continue with a number of these smaller projects in tandem, so the end outcome may well be the same albeit encapsulated in two plans rather than one. The major omission of the majority of the transport provisions is the subject of a further study.

The Draft CCP and the approved blueprint have both been led by urban designers and shaped by urban design propositions, in particular a low-rise, more intensively developed city based on economic factors with high quality green and public spaces shaped for people. The extent to which they can replicate the success of the Lisbon reconstruction is at least in part subject to international economic forces and remains to be seen. Equally important is the clarity developed around future urban design controls. While these exist in the Draft CCP, the minister has side-stepped council involvement in consent processes and set up a new consent authority to oversee central-city consents, with one representative each from the council, CERA and Ngai Tahu, (with no articulated formal role for Christchurch City Urban Design Panel). This body has a mandated consent turnaround of 5 working days as compared to the usual 20- to 85-day timeframe (depending on levels of compliance).

The top-down process enacted in the Lisbon earthquake or more recently the Kyoto earthquake, and the bottom-up process followed after Hurricane Katrina, sit at either extreme of the continuum of possible response management strategies to natural disasters. A balance between these extremes is more feasible, the balance depending on the socio-cultural and economic context and the governance systems in place at the time of the crisis.

Communication Technologies have had a major impact on response capability in the intervening centuries between Lisbon and Christchurch. Tsunami early warning systems and international media networks give instant alerts of impending disasters allowing preparation

or evacuation. Cell phone networks, satellite communications and GPS tracking and positioning technologies contribute to more effective search and rescue operations. Collective media and social network platforms pressure reconstruction authorities to deliver on their promises in a timely manner. The internet collapses the time required for widespread public consultation leading to more effective community buy-in into new urban proposals.

In Christchurch, the lack of alternative design proposals from official sources has been a response to the short timeframes imposed by the government. This is less concerning or necessary given the wide consultation undertaken to reach the plan outcome. Again in spite of the 250-year separation and with different professional actors, Lisbon and Christchurch had good levels of technical expertise available to generate an urban design-led reconstruction effort using current contemporary urban theory around sustainability and resilience planning in combination with deep local knowledge.

The technical planning and architectural detail is not yet present in the Christchurch plan and will be managed by planning consent processes that have not yet been well defined. Lisbon provides an excellent model for reinventing a modern local urban type (a mixed-use, low-rise, multi-tenancy, structurally sound and fire-protected building) and designing an urban block morphology that reflects a historical vernacular. This will be the fabric that weaves the plan framework and the demonstration projects into a real city.

New Zealand government agencies in charge of engineering, building and construction standards have not yet integrated the lessons from the 2010 and 2011 earthquakes into upgraded performance codes. As a nation located on a chain of islands on the Pacific 'ring of fire', uptake of resilience strategies like those in enlightenment Portugal must encompass flexible governance systems, high-level technical expertise in national, regional and urban planning sectors, and innovative architectural, communications, engineering and material technologies. This in combination with communities helping themselves is the best insurance against future calamity.

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References

- [1] Baptista, M., Miranda, J., Miranda, L. and Mendes V. (1996) Rupture Extent of the 1755 Lisbon Earthquake Inferred from Numerical Modeling of Tsunami Data, *Physics and Chemistry of The Earth*, 21/ 1-2, pp.65-70.

- [2] Araújo, A. (1997) *A Morte em Lisboa. Atitudes e Representações, 1700-1830* (Lisbon: Editorial Notícias).
- [3] Voltaire (1759) *Candid, or All for the Best* (London, J. Nourse).
- [4] Kostof, S. (1991) *The City Shaped: Urban Patterns and Meanings Through History* (London, Thames and Hudson).
- [5] Maxwell, K. (1995) *Pombal, paradox of the Enlightenment* (Cambridge, Cambridge University Press).
- [6] Hamblyn, R. (2009) *Terra, tales of the earth: four events that changed the world* (London: Picador).
- [7] Araújo, A. (2006) 'The Lisbon Earthquake of 1755-Public distress and political propaganda', *e-JPH* 4/1 pp10.
- [8] Esperjo, C. (2005) 'Spanish news pamphlets on the 1755 earthquake: trade strategies of the printers of Seville' in T. Braun and J. Radner (eds) *The Lisbon earthquake of 1755: Representations and reactions* (Oxford: SVEC: 66-80).
- [9] Voltaire (1759) *Candid, or All for the Best* (London, J. Nourse).
- [10] Frèches, C. (1982) 'Pombal e la compagnie de Jésus: la compagne de pamphlets', *Revista de História das Ideias*, 4/1: 299-327.
- [11] Diogo, M. (2001) 'Ciência Portuguesa no Iluminismo: Os estrangeirados e as comunidades científicas europeias' in J. Nunes e M. Gonçalves (eds.) *Enteados de Galileu? A semiperiferia no sistema mundial da ciência* (Porto: Afrontamento: 209-238).
- [12] Kagan, R. (2000) *Urban Images of the Hispanic World 1493-1793* (New Haven, Yale University Press).
- [13] Teixeira, M. C. and Valla, M. (1999) *O Urbanismo Português: Séculos XIII-XVIII : Portugal-Brasil* (Lisboa, Livros Horizonte).
- [14] Sepúlveda, C. (1910) *Manuel da Maya e os Engenheiros Militares Portugueses no Terremoto de 1755* (Lisbon: Imprensa Nacional).
- [15] Ratton, J. (1813) *Recordações de...sobre occurencias do seu tempo em Portugal durante o lapso de sessenta e tres annos e meio...*(Lisbon, Fenda 1992)
- [16] Manuel da Maia, *Dissertação Part I, Part II and Part III (1755-56)* in J. França (1977) *Lisboa pombalina e o Iluminismo* (Lisboa: Bertrand).
- [17] Rossa, W. (2008) 'On the first plan' in A. Tostões. and W. Rossa *Lisboa 1758: The Baixa Plan Today* (Lisbon, Lisbon Municipal Council).
- [18] Rossa, W. (1998) *Beyond Baixa: Signs of Urban Planning in Eighteenth Century Lisbon* (Lisbon, Instituto Português do Património Arquitectónico).
- [19] Kostof, S. (1991) *The City Shaped: Urban Patterns and Meanings Through History* (London, Thames and Hudson).

- [20] Montiero, C. (2008) 'Laws written evenly along straight lines' in A. Tostões. and W. Rossa *Lisboa 1758: The Baixa Plan Today* (Lisbon, Lisbon Municipal Council).
- [21] Murteira, H. (1999) *Lisboa da Restauração às Luzes* (Lisboa: Editorial Presença).
- [22] Montiero, C. (2008) 'Laws written evenly along straight lines' in A. Tostões. and W. Rossa *Lisboa 1758: The Baixa Plan Today* (Lisbon, Lisbon Municipal Council).
- [23] Silva, R. (2008) 'Lisbon rebuilt and expanded 1758-1903' in A. Tostões. and W. Rossa *Lisboa 1758: The Baixa Plan Today* (Lisbon, Lisbon Municipal Council).
- [24] Subtil, J. (2007) *O Terramoto Político (1755-1759); Memória e poder* (Lisboa: Universidade Autónoma).
- [25] Almeida P. (1973) 'A arquitectura do século XVIII em Portugal: pretext e argumento para uma aproximação semiológica', *Bracara Augusta* (Braga: Câmara Municipal de Braga 64/76 / XXVII / II:456).
- [26] Barreiros, M.H. (2008) 'Urban Landscapes: Houses, Streets and Squares of 18th Century Lisbon', *Journal of Early Modern History* 12, pp. 205-232.
- [27] Teixeira, M. C. and Valla, M. (1999) *O Urbanismo Português: Séculos XIII-XVIII : Portugal-Brasil* (Lisboa, Livros Horizonte).
- [28] McKinnon, M. (ed)(1997) *New Zealand Historical Atlas* (Auckland: David Bateman).
- [29] Canterbury Earthquake Recovery Act 2011: <http://www.legislation.govt.nz/act/public/2011/0012/latest/DLM3653522.html>
- [30] Christchurch City Council, Draft Central City Plan 2011: <http://resources.ccc.govt.nz/files/CentralCityDecember2011/FinalDraftPlan/FinaldraftCentralCityPlan.pdf>
- [31] Canterbury Earthquake Recovery Authority 2011: <http://cera.govt.nz/government-response-to-the-august-2011-draft-of-the-central-city-plan>
- [32] Christchurch Central Recovery Plan 2012: <http://ccdu.govt.nz/the-plan>
- [33] Davoudi, S., et al (2009) *Planning for Climate Change: Strategies for Mitigation and Adaptation*, London: Earthscan.
- [34] Earthquake Commission 2012: <http://canterbury.eqc.govt.nz/faq>
- [35] Muir-Wood, R. (2012) The Christchurch Earthquakes of 2010 and 2011 in Courbage, C. and Stahel, W. *The Geneva Reports-Risk and Insurance Research No 5, Extreme Events and Insurance, 2011 Annus Horribilis*, (Geneva: The Geneva Association).
- [36] Macfie, R. (2012) Frustration and Rage, *New Zealand Listener* September 18-14: 25-31.