# AN ALTERNATIVE MODEL FOR URBAN RENEWAL: A GENERATIVE APPROACH TO THE (RE)-DEVELOPMENT OF XIAN VILLAGE

LING KIT CHEUNG[1], ZHITAO XU[2], PEI CHEN[3] and MOHAMMED MAKKI[4]
[1,2,3,4]*University of Technology Sydney.*
[1]*lingkit.cheung-1@student.uts.edu.au, 0000-0001-5040-8686*
[2] *Zhitao.Xu@student.uts.edu.au, 0000-0002-0541-6780*
[3]*Pei.Chen-1@student.uts.edu.au, 0000-0003-2677-3565*
[4]*Mohammed.Makki@uts.edu.au, 0000-0002-8338-6134*

**Abstract.** The impact of urban renewal, specifically in countries experiencing rapid urbanisation due to population growth, has resulted in the erasure of urban culture and heritage in favour of repetitive homogeneity that has been synonymous with 20th century modernist planning models. One such region experiencing this rapid urban renewal is the Guangzhou region in southern China. The presented experiments examine Xian Village in Guangzhou, a culturally rich urban tissue currently experiencing redevelopment, and proposes an alternative model for urban renewal, employing a bottom-up approach to urban growth through the use of a multi-objective evolutionary model; presenting a model that integrates historic and existing urban characteristics adapted to future development plans.

**Keywords.** China, Guangzhou; Xian Village; Village in the City; Urban Renewal; Cultural and Heritage Preservation; Multi-Objective Evolutionary Algorithm (MOEA); SDG 10; SDG 11; SDG 13.

## 1. Introduction

The complexity of urban form, coupled with a rapidly changing climate and an exponentially growing population, has highlighted the demand of understanding this complexity through bottom-up approaches rather than top-down systems (Batty, 2008), in which the rationalisation of the urban fabric is achieved through local rules in favour of global order (Weinstock, 2010). Culture and heritage plays a vital role when examining this urban complexity, a relationship discussed by many throughout the 20th century; from Gustavo Giovannoni, who equated the value of urban heritage to that of urban development (Giovannoni, 1913), to Patrick Geddes, who emphasised the understanding of the city in both its growth and life (Geddes, 1915), to Lewis Mumford, who emphasised the relationship between people and the city (Mumford, 1935), and to Jane Jacobs, who was one of the first voices against the 'city as a machine' (Jacobs, 1961). However, environmental changes, specifically related to population growth in countries experiencing rapid urbanisation (e.g. China, India and

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South Africa), have led to a growing pattern of 'cultural erasure' and 'urban replacement' throughout the 21st century (Kiruthiga and Thirumaran, 2019). Cities that can no longer 'adapt' to environmental stresses often prompt the demand to rebuild, erasing the old and replacing it with what is deemed suitable for near future. In doing so, the historical significance of culture and heritage of the existing is discarded.

This paper examines these phenomena by reimagining Xian Village, a 'village in the city' in China undergoing this culture erasure, through the design of an urban tissue that retains the urban characteristics of the existing village yet integrates it to the surrounding city currently experiencing rapid urban renewal. In addition, the presented experiment examines three UN SDGs; firstly, addressing the inequality between the inhabitants of Xian village and those surrounding it (SDG 10); secondly, through a more sustainable approach to urban living by integrating design goals that support the end users of the city, with a primary focus on pedestrian activities (SDG 11); and finally, climate response through utilising environmental and climatic design goals and analytic criteria as primary drivers in the conducted experiment (SDG 13).

## 2. Research and Background

### 2.1. ERASURE OF CULTURE IN FAVOUR OF NEW DEVELOPMENT

In China, especially the southern regions, rapid urbanisation has created a phenomenon called 'village in the city' (ViC). They are formed when villages located in the suburbs are surrounded by rapid urban redevelopment, frequently transformed into small pockets of under-developed superblocks (Liu, 2019). These ViCs are infamous for their dense, compact and oftentimes illegal structures due to population demands. They are regarded by some as "an obstacle to the transformation of a modern metropolis, an eyesore in a well-planned city" and are slowly being demolished and re-developed (Nanfang Daily, 2000). In the last two decades, many ViCs in the Guangzhou region have experienced redevelopment, in which heritage-rich urban fabrics have been replaced by modernist urban models. One such example is 'Xian Village'; an urban tissue that represents the struggle between a decentralised, bottom-up urban fabric failing to adapt to the speed of growth and demands of urbanisation, inevitably leading to its destruction in favour of top-down, centralised urban form.

### 2.2. XIAN VILLAGE

Xian Village, settled over 800 years ago, is one of the remaining ViCs in the Guangzhou region, and thus a critical urban tissue to examine. Analysis into the village is presented through two scales, the macro (i.e. the relationship of the village to its surrounding context), and the micro (i.e. the inner workings of the village itself). In the macro scale, the rapid urbanisation of the city around Xian village has generated various challenges. The village is surrounded by 4 arterial highways with only 2 pedestrian walkways, cutting off accessibility to the village and limiting pedestrian movement between the village and the surrounding blocks (Figure 1). The contrast between the building typologies of the village and the surrounding blocks is vast, revealing a high disparity of density and functionality within the urban form (Figure 1). Most importantly, the village represents centuries of cultural and historical value, a trait not retained by the surrounding context. In the micro scale, Space Syntax centrality analysis (Hillier and Hanson, 1984) of the village reveals that despite the seemingly chaotic streetscape, most of the paths were well utilised by the village's inhabitants. The majority of the inner streets are pedestrian-only streets due to their width, with commercial shops and street vendors located on either side and cantilevering residential buildings overhead, limiting the skyview factor from street level. The narrowness of the network creates fire and safety risks, as well as minimal sun exposure to the street. The building typologies within the village, primarily a result of increasing population numbers, allowed for increased levels of interaction between the inhabitants (Figure 1).

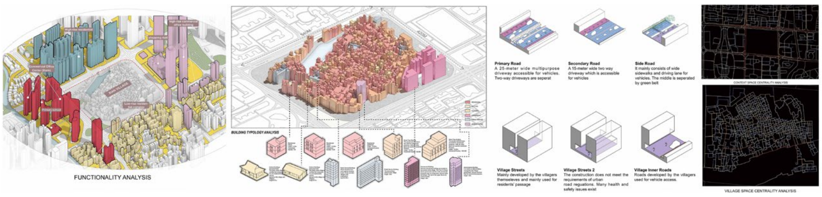


*Figure 1. Xian Village typology and network analysis*

Throughout the village, there are two primary urban typologies that hold significant value to the inhabitants; ancestral halls and local markets. Regarding the former, there are 5 ancestral halls located within the village, these are Chinese traditional ceremonial halls where ancestors are worshipped and serve as the cultural focal point of the village. Regarding the latter, markets are one of the lifelines of the village and play a vital role in its urban heritage. However, the lack of usable space within the village forced vendors to occupy the streets regardless of the availability of a storefront, resulting in a lack of regulation throughout the village.

## 3. Method

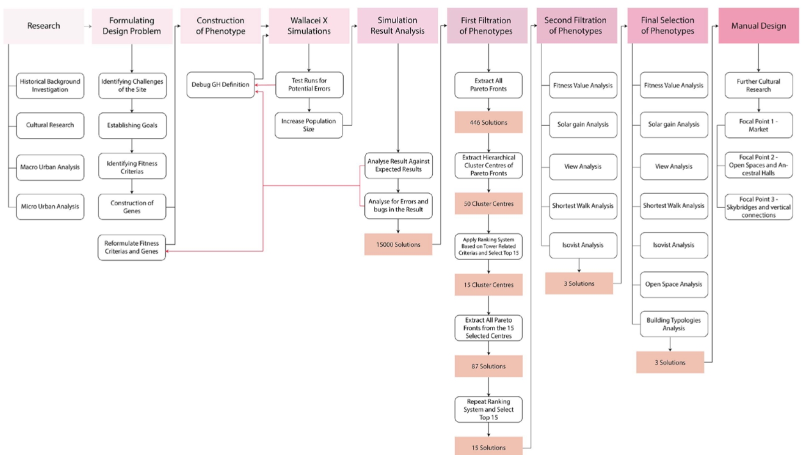


*Figure 2. Pseudo Code (workflow methodology)*

The presented experiment utilises a Multi-Objective Evolutionary Algorithm (MOEA) to generate an urban superblock that addresses Xian Village's high population density, while maintaining its existing cultural elements, heritage buildings and the connectivity between the residents as a community. The experiment is presented through 4 key stages (Figure 2); formulation of the design problem, in which the chromosomes, fitness objectives and phenotype are developed; running the MOEA and debugging (requiring several rounds of reformulation); analysis of the results outputted by the algorithm; and finally, analysis of the selected solution.

## 4. Experiment Setup

### 4.1. CONSTRUCTING THE PHENOTYPE

The phenotype is a reconstruction of the Xian Village superblock, with an emphasis on various characteristics such as cultural heritage, population density, building typologies, street network and site context. To retain the existing features within the superblock and adopt new urban features, the construction of the phenotype is divided into four key stages: Identifying podiums, towers, buildings and bridges.

The phenotype sits within the existing site boundaries (560mx440m), which is divided into a 15m by 11m grid, mimicking Xian Village's original scale. The parameters (chromosomes) defining the phenotype's morphology, and controlled by the algorithm to create variation, are the following (Figure 04): The size of each cell in the grid (by manipulating the corner points of each cell in the X and Y); the size and location of podiums (by clustering cells together); location of towers and their rotation in response to the ancestral halls; height of buildings on the podiums; size, orientation and shape of ground level buildings (cells are divided, rotated and merged); defining street network (by identifying routes between ancestral halls); location and size of lakes (according to proximity to ancestral halls); heights of ground level buildings according to relationship to ancestral halls; location of bridges between podiums, as well as between towers to each other, and towers to the context (i.e. the site outside the village).

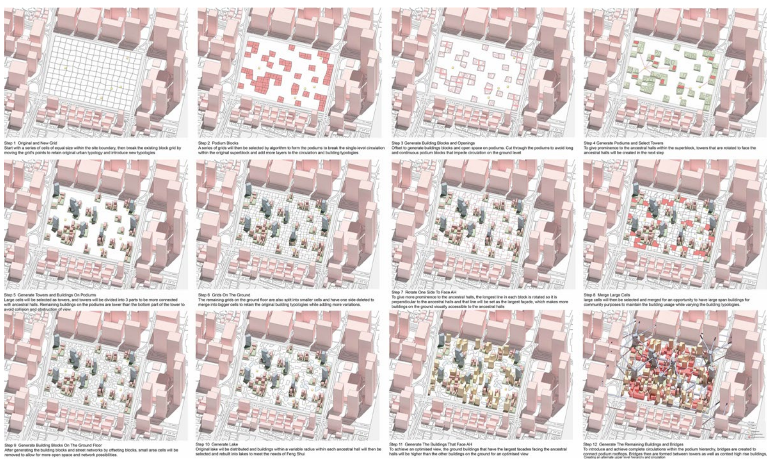

*Figure 3. Phenotype Construction Process*

There are additional parameters 'hardcoded' (i.e. not controlled by the algorithm) into the phenotype's construction; these include the deletion of cells with an area that falls below a certain threshold and the division of tower heights into three parts and rotating each part accordingly (lowest part, which is residential, does not rotate; middle part, offices, rotates towards the closest ancestral hall; and the top part, cultural, is oriented towards the ancestral hall) (Figure 3).

### 4.2. FITNESS OBJECTIVES

In addition to the chromosomes defining the phenotype's morphology, to generate an urban tissue that addresses the demands of population growth, retention of cultural heritage, improved social spaces (public space and solar access) and greater connectivity to the external context, 4 fitness functions have been identified to drive the MOEA: 1. Maximise open space on ground and podium rooftops; 2. Maximise population density; 3. Maximise views to ancestral halls and lakes; 4. Maximise solar exposure on ground level and on building facades.

### 4.3. SIMULATION SETTINGS

The MOEA used for the experiment is the NSGA-2 algorithm developed by Kalyanmoy Deb (Deb et al., 2000) within the software Wallacei (Makki et al., 2018), a plugin for Grasshopper 3D. The simulation was run on a high-end consumer-grade PC, running with Windows 10 Home 64-bit (Version 21H2 / DirectX 12), AMD Ryzen 9 5900X 12-Core Processor (24 CPUs threads)- 4.20 GHz with 32.0 GB of RAM, Asus TUF GAMING X570-Plus and NVIDIA GeForce RTX 3080 graphics card.

## 5. Experiment Results and Selection Process

### 5.1. ALGORITHM RESULTS

The Algorithm ran a population comprised from 300 generations with 50 individuals in each generation, totalling 15000 solutions with a simulation runtime of 30 hours and 37 minutes. Analysis of the results and charts outputted by the simulation highlights that all objectives improved in mean value throughout the algorithmic run. Whereas objectives 2 and 3 (population density and views to ancestral halls) demonstrated greater convergence when compared to objectives 1 and 4 (open space and solar gain),

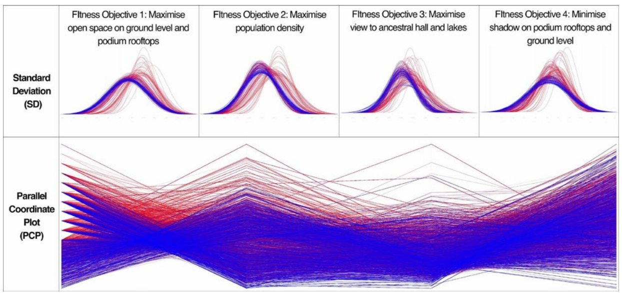


*Figure 4. Algorithm Results (Top: Standard Deviation Graph, Bottom: Parallel Coordinate Plot)*

analysis of the results through the parallel coordinate plot presents lower conflict between objectives 2 and 3, allowing the algorithm to potentially favour these two objectives over the others (thus resulting in greater convergence). From the 15000 solutions generated by the algorithm, 446 comprised the pareto front. These pareto solutions were extracted and analysed further in the selection process presented in the following sections (Figure 4).

## 5.2. SELECTION PROCESS

The MOEA resulted in a large number of pareto front solutions, thus necessitating a thorough selection process to 'filter' through the 446 pareto front solutions and select one. As such, a three-stage selection process has been applied to the pareto front solutions, with each stage analysing the solutions through different scales and criteria.

### *5.2.1. First Selection Matrix*

| Item # | 40-0 | 70-2 | 73-45 | 77-49 | 83-48 | 93-13 | 104-17 | 104-34 | 112-43 | 117-24 | 124-21 | 125-3 | 139-33 | 217-47 | 268-48 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Towers | 7 | 7 | 5 | 7 | 6 | 5 | 6 | 7 | 6 | 6 | 5 | 5 | 7 | 7 | 7 |
| Sky Bridges | 16 | 12 | 7 | 11 | 11 | 8 | 11 | 12 | 10 | 7 | 6 | 5 | 13 | 11 | 11 |
| Lowrise (large) buildings (0.5 pt) | 2 | N | N | 1 | 2 | 6 | 3 | 6 | N | 4 | 6 | 6 | 4 | 1 | N |
| ^ (-0.5 pt per building if over 3) | | | | | | -1.5 | | -1.5 | | -0.5 | -1.5 | -1.5 | -0.5 | | |
| North to South connection (1 pt) | Y | Y | N | Y | Y | Y | Y | Y | N | N | N | N | Y | Y | Y |
| East to West connection (5 pt) | Y | Y | N | N | N | N | N | N | Y | N | N | N | N | N | Y |
| 15 adjacent grids empty of bridges (-5 pt) | | | -5 | | | | -5 | -5 | | -5 | -5 | -5 | -5 | | |
| Score | 30 | 25 | 7 | 19.5 | 19 | 15.5 | 14.5 | 16.5 | 21 | 9.5 | 7.5 | 6.5 | 17.5 | 19.5 | 24 |

*Figure 5. Results of first selection matrix*

In the first round of selection, the pareto front solutions were clustered using hierarchical clustering (average linkage) into 50 clusters (using the 4 fitness values for each solution). The solution at the centre of each cluster (which in this case is determined to be the representative of the cluster) is selected and ranked based on tower-related criteria (number of towers, sky bridges, low-rise and large buildings, north to south connections and east to west connections (the latter is prioritised as it connects the two neighbouring CBD blocks) and consecutive blocks without bridges overhead). Each solution is given a new ranking and the top 15 cluster centres are selected. The process is then repeated to all the solutions that belong to these 15 cluster centres (a total of 87 solutions), and scored once more, selecting the top 15 solutions for the second round of selection (presented in Figure 5).

### *5.2.2. Second Selection Matrix*

In the second round of selection, the 15 selected solutions were analysed further, in which 5 of the 15 solutions were culled as they did not demonstrate sufficient connectivity to the external context of the urban tissue (these are highlighted in grey in Figure 5). The remaining 10 solutions are analysed according to additional criteria; these include their fitness diamond chart (i.e. the relationship of the four objectives for each solution), phenotypic characteristics, solar exposure on building facade and low-rise building roofs, solar exposure on ground and podium rooftops, views to ancestral halls, shortest walk between ancestral halls and to site boundary, isovist occlusivity and isovist min.radial using decoding spaces plugin (CPlan, 2021) (Figure 6). Each solution was given a new ranking, and the top 3 solutions were selected.

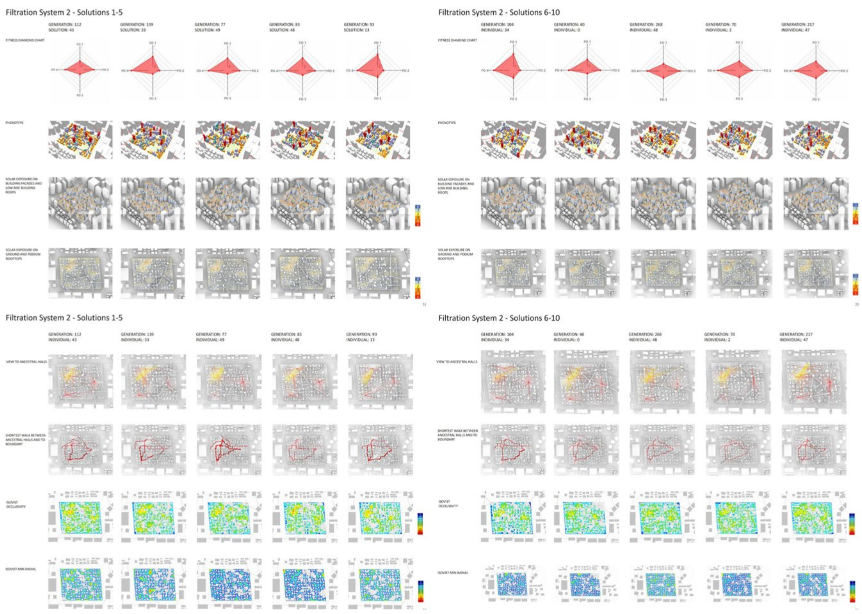


*Figure 6. Results of second selection matrix*

### *5.2.3. Third Selection Matrix*

In the final round, the 3 selected solutions were analysed further with the following criteria: Total number of podium open space, total area of podium open space, total area of ground open space, total solar gain on ground, podiums and building facades, view to ancestral halls, shortest walk between ancestral halls and to site boundary, isovist occlusivity and isovist min.radial, population density)

The results of the third selection round present solution 2 (gen.70/ind.2) as the most favourable solution (Figure 7). Solution 2 demonstrates greater solar gain (on streets, podiums and building facades), as well as improved views on ground level throughout the urban tissue (as per the results of the occlusivity analysis). Pedestrian access on street level between ancestral halls as well as between public spaces performs better, and so does the connectivity to the site boundary (on ground level) and to the external context (through bridges on upper levels). As such, solution 2 was selected as the most optimal solution for the design objectives and assessment criteria defined in the simulation, and analysed further at 3 different scales to better understand the architectural urban impact of the selected solution.

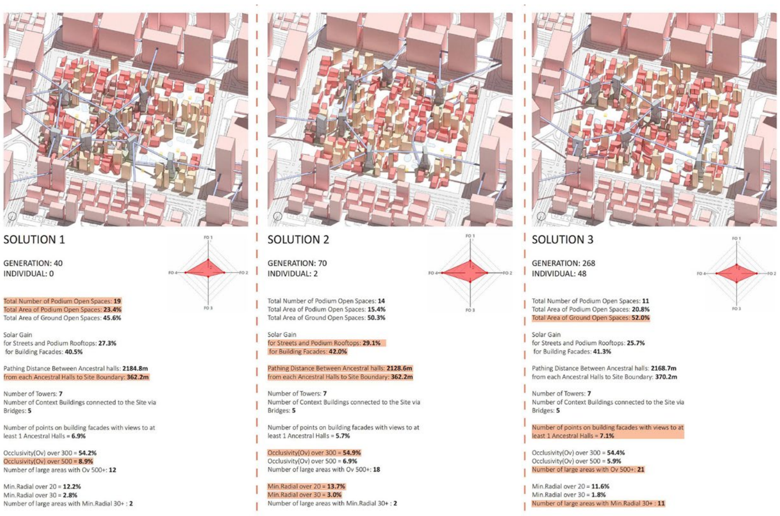


*Figure 7. Results of third selection matrix. Solution 2 (middle) selected as the most optimal.*

## 6. Selected Solution Analysis

The two vital cultural typologies of Xian Village, ancestral halls and markets, were further developed to illustrate a more detailed urban character of the selected solution. Three focal points, at different scales, are selected to demonstrate the qualitative aspects of the cultural typologies and their impact on the users of the space.

### 6.1. FOCAL POINT A - NEW MARKET SPACE

Focal Point A addresses the markets and street vendors of Xian village. The lack of store fronts and defined market space results in a haphazard occupation of the street. To maintain the flexible character of the street vendors, an adaptive module is integrated within the market space allowing for improved order while maintaining flexibility and growth (Figure 8). The module allows for the occupation of both public open space as well as narrow streets throughout the village. Ramps on the podium façades generate greater interaction between the ground floor and podium roof top (Figure 8), allowing for easy access between the two (both physical and visual).

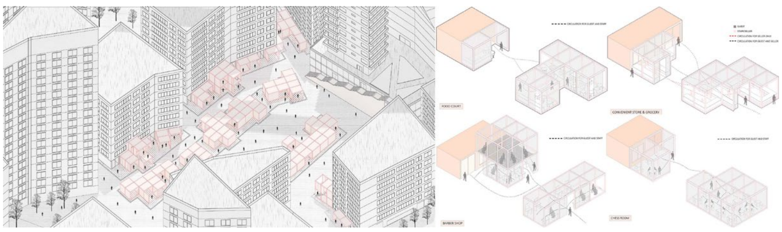

*Figure 8. Focal point A: perspective and top view*

### 6.2. FOCAL POINT B-ANCESTRAL HALLS OPEN SPACE

Focal point B explores the interaction between Ancestral Halls and lakes and the division of open spaces to cater to different functions. Open space throughout the village is defined into three categories: public squares, green spaces, and recreational areas near community building clusters. Selected open spaces near the site boundary are allocated as collection points for public transport, as well as car parks, allowing for the majority of the internal streets of the site to be pedestrian only (Figure 9).

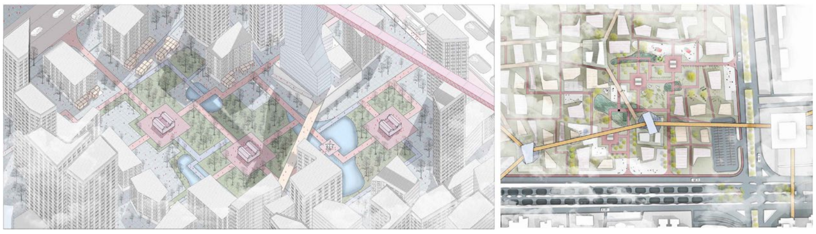

*Figure 9. Focal point B: perspective and top view*

### 6.3. FOCAL POINT C-SKY BRIDGES

The last focal point explores the vertical connections between sky bridges and buildings, and the edge conditions of the site and context. Figure 10 illustrates the circulation hierarchy of ground, podium bridges and tower bridges. A detail of the interaction between the podium bridges and the buildings is also illustrated. The point of contact between the two is converted into a public space allowing for more accessibility and interaction; equally activating both the ground level and bridge level.

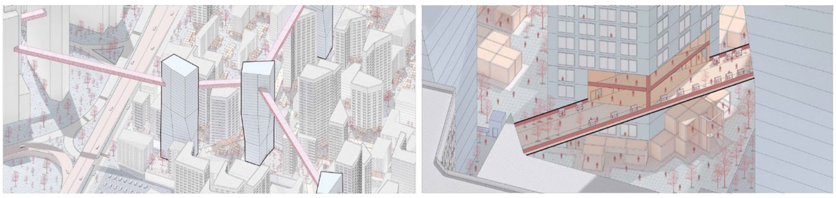

*Figure 10. Focal point C: perspective view and detailed bridge to building relationship*

## 7. Discussion and Conclusion

The presented research examines the increasing trend in countries experiencing rapid urbanisation of replacing culturally rich and historic urban tissues with modernist urban models. Through the use of evolutionary methods, there is an emphasis on the utility of bottom-up systems that address local conditions and relationships between various morphological characteristics within an urban patch, in which the complexity of city design is approached through localised decisions (in the presented experiments, the chromosomes and genes that define the phenotype) that reflect the end user of the space. At every stage of the experiment presented (phenotype construction, analysis of results, selection and filtration and local analysis of the selected solution), the aim of retaining the village's cultural urban characteristics while integrating it with its urban environment was the primary driver throughout.

In the analysis of the three focal points in the selected solution, the evolved urban tissue demonstrated improved public awareness of ancestral halls through improved accessibility (both physical and visual) throughout. Open space on both ground and podium level with increased solar access contributes to one of the key cultural characteristics of the site, the markets, while the activation of the bridges connecting podiums and external context allows for greater integration to the surrounding site.

The experiment puts forward an alternative model of urban redevelopment that examines urban heritage within a superblock; identifying key elements of cultural significance and optimising it through a MOEA followed by a thorough selection mechanism, there were key limitations however, both in the formulation of the computational setup as well as the resulting solution. The criteria implemented in the first round of selection was unsuccessful in detecting solutions that lacked integration to the surrounding site, indicating the necessity for a reformulation not only of the design problem, but also the selection criteria as well. Although the selected solution addressed the various criteria used for its assessment, further work is required to address issues surrounding energy consumption (at different scales) throughout the superblock, as well as improved integration between the context and superblock at street level. Where the integration of bridges addressed this on upper levels, the positioning of buildings throughout the perimeter of the selected solution limits its integration to the surrounding. Finally, future research on the quantification of cultural and social characteristics, and its impact on urban form, is required to strengthen the presented model in order to continue to address and reverse urban cultural erasure.

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