

Restoration of Historical Fair-faced Brick Facade in Tianjin Five Avenues, PR China

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ABSTRACT

The Tianjin Five Avenues are located in the city centre of Tianjin, where more than 2000 different styles of historical European-Chinese mixed architecture built in 1920-1930s have been identified and listed as architectural and historical monuments. The most characterized is fair faced brick façade of Arts & Crafts. Almost all kinds of bricks including refractory stones, clinkers imported from Europe, red clay bricks, pimple bricks with melting rough surface and traditional Chinese green-grey clay bricks etc. have been used as decorative finishing. Especially the pimple bricks with melting and very rough surface and dark grey-purple colour have not been found in other regions in China. The masonry mortar is almost unique mixture of lime and clay (earth) with a mix ratio of 20-30% lime plus 70-80% earth in weight. The pointing materials are historically cement-based to clinkers but pure lime to clay red-grey brick façade. The pointing of most clinkers has a recessed form up to 5-20 mm, but the traditional Chinese-style bricks have flat or modelled form of lime mortar. One of the most common defects is rising dampness due to failed damp barrier based on bituminous paper. Another defect is leakage and freezing and thaw caused by fissures and cracks especially fine cracks between stones and joints, which are more or less related to earthquakes in 1976. Based on the comprehensive architectural and material researches, a system for restoration of the unique brick façade has been developed with affordable budget for riutilisation of those heritage buildings. This is called function-oriented concept which includes installation of rising dampness barrier through chemical injection, structural strengthening using RFC, brick restoration, repointing using lime-based mortar, water repelling impregnation etc.

Keywords: *Five Avenues Tianjin, Historical Architecture, Fair Façade Brick Façade, Rising damp, Repointing*

1. INTRODUCTION

1.1. Tianjin Five Avenues

The Tianjin Five Avenues (not Fifth Avenue) refer to an area of over 100 hectares near City Centre, which is located in south of Chendu Ave, east of Xikan Ave, west of junction of Machan Ave and Nanjin Ave.

In this area more than 2000 different styles of historical European-Chinese mixed architecture built in 1920-1930s have been identified and among them, 409 have been listed as architecture heritage and 101 as cultural monuments and sites.

They are telling the history of modern China, especially the social reforms happened at the end of the feudal monarchy and the journey of the democratic revolution since the Revolution of 1911.

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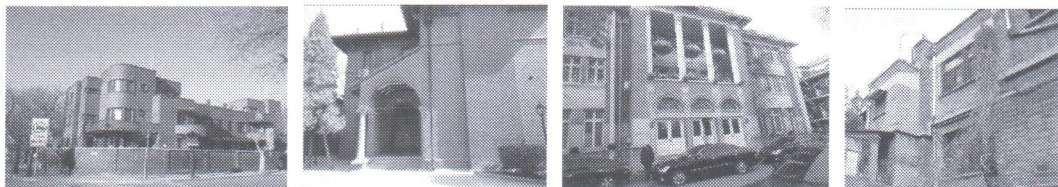


Fig. 1 some of representative historic building of Arts & Crafts in Tianjin Five Avenues from well preserved (left) to in very poor condition (right)

However most of the heritage buildings especially those were occupied by normal residents are in poor conditions not only due to natural disaster like earthquake.

From 2008 under the financial support of Tianjin Municipal Bureau of Land Resources and Housing Administration, a team from Tongji University, Tianjin Historical Architecture Restoration and Development Co Ltd. and 2 other material and engineering cooperates from Shanghai have investigated the development of materials used during construction and subsequent restoration, defects, pathology of buildings and affordable technology for restoration for the reutilisation of all

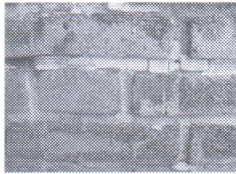
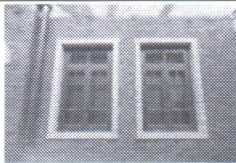
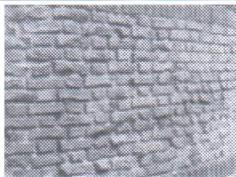
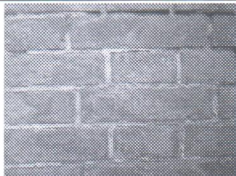



historic buildings. This paper is a summary of phase 1 research results. Further research works for cellar restoration and eco-modernisation in coleration with some German Universities are still on-going.

2. Material performance and the development of brick masonry

2.1 Bricks

At least 7 kinds of bricks have been found in the Tianjin Five Avenues (Table. 1). Those bricks have proven the multi architectural culture of 1920-1930's in Tinajin.

Table 1 Masonry bricks founded in 5 Avenues in Tianjin

Type	Charateristics	Foto documentation	Form and materials of Joints	Water sbsorption coefficient (kg/m ² ·h ^{1/2})
Clinker	Well selected raw material, densely moulded and burt at high temperature, smooth surface, colour red-pubble. Used in the architecture buit in 1920's. It was said to be imported from Europe or mmanufactured exactly according to European Standard.		Deep recessed, cement based	6.2-26.7
Refractory stones,	Very dense moulded and burt at high temperature with colour of light orange-beige		Deep recessed or flat, cement-based	2.7-5.6
Pimple bricks	pimple bricks with melting rough surface and sandy texture (rich in sand and ???) with rich colour from black to purple to orange.		Very deep recessed, cement-based	Same as clinker
Red clay brick	Well selected rich in clay , colour red-orange-yellow		Flat, lime putty	Aap. 10
Green-grey brick	Rich in clay minerals, burt at low temperature, quenched with grey-green up to yellowish		Modelled, lime with fibre	App. 13
Rouge stone	A kind of multi-coloured due to different temperature and oxidisation condition		Flat, cement based	Similar to red clay brick
Sandy clinker	A kind of brick rich in sand and a very rough surface, colour from dark braun to beige-orange		Flat up to recessed, cement-based	Not analysed

2.2 Bedding mortar and joints

All masonries of various stones were laid with almost the same masonry mortar, a mixture of earth from Haihe (a river crossing the city of Tianjin) and lime. The lime and earth mix ratio ranges from 1:3 (very slim) up to 2:1 (very fat) based on the chemical analysis with help of the "Wisser & Knoefel" method.

The means, during the construction time, no quality control had been given to the masonry materials. The bedding mortar is very porous and has very high water absorption capacity, this provide an economic possibility to be treated against rising dampness. Original rising damp barrier was bituminous sheets, which is rotted and has lost its function.

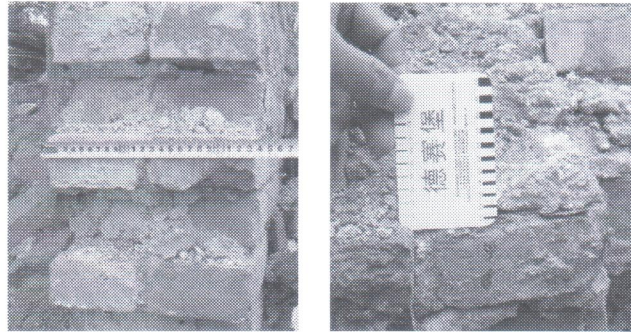


Fig. 2 Construction of masonry built with lime-earth mortar (left) and bituminous sheet (right) as rising damp barrier

However, due to availability of the cement, mostly because the earliest cement manufacturer was located app. 100km from Tianjin, most of clinker facades were pointed with cement-based joint mortar, while the traditional green-grey bricks were pointed with modelled joints, which are composed of pure lime and hemp fibres (1-2%) and round finishing (Tab. 1). All the joints are in relative good original condition, unless there are affected by water or moisture.

2.3 Defects

The most common defects of the fair faced brick facade in Tianjin Five Avenues are caused by moisture, e. g. rising dampness or leakage of rain water down pipes due to poor maintenance. Some of the walls have suffered irreversible damage from water penetration and freezing, causing the faces of many bricks to pop off.

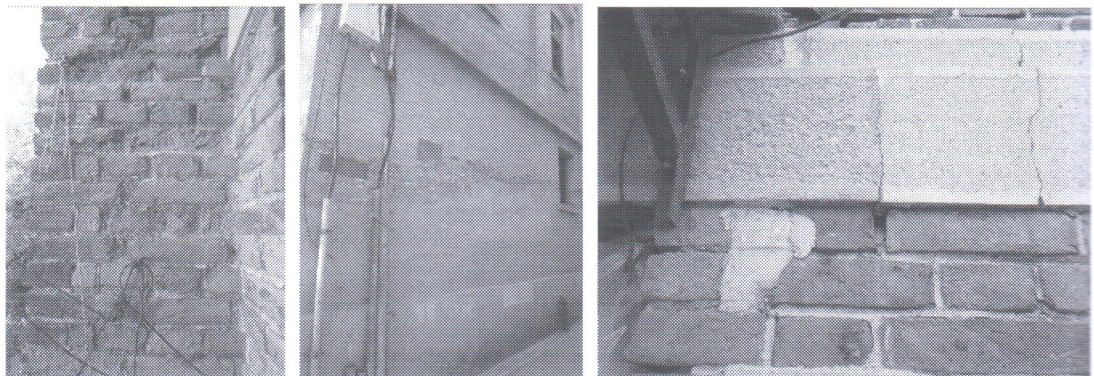


Fig.3 various defects might be related to freezing thaw (left)、rising dampness and wrong restoration methods (middle) and movement (earth quake, right)

Due to very deep recessed points, most of fair faced brick facades are not rain water tight. This is one of the reasons that most of the facades are painted with emulsion paints or transparent glossy sealers or even bituminous coatings in the past

decades. Because of leakage, some of bricks were re-pointed with new pure cement, which is neither physically nor chemically compatible to original. This is not only visual defects, but also

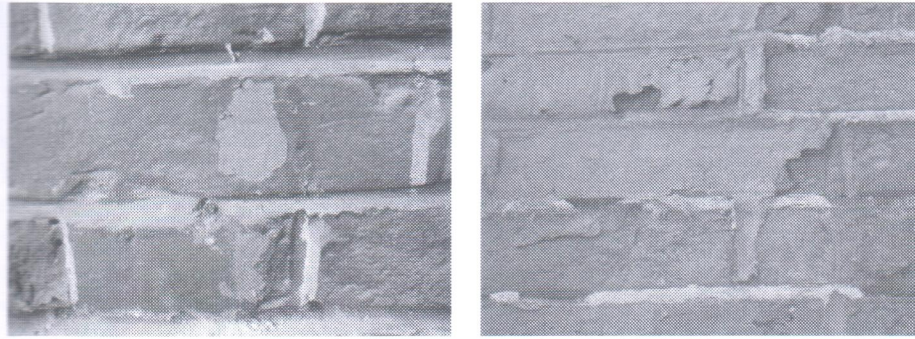


Fig 4 (left) Painted fair-faced brick facade, the stone was painted with dark braun colour, joints with white light grey coating, but historically the joint colour was dark grey – beige after natural weathering; (right) green-grey brick with white modelled joints was painted by grey coating

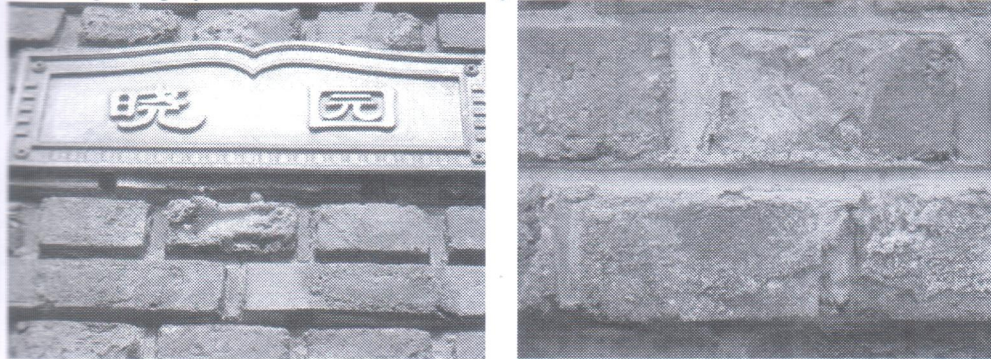


Fig 5 Original deeply recessed joints (left) and repaired with cement which damages entire image of brick facade

3. Restoration technology - “new function oriented restoration”

The research works of Phase 1 during 2009-2012 were to carry out comprehensive study to understand the historic construction materials itself, reasons of defects and to work out restoration concept. The developed concept for the restoration of fair-faced brick façade should meet the new function of restored historic buildings in terms of stability, entity and water tight. All applied restoration technology should be functional, i. e. will solve current problems, but financially affordable. This concept is called “new function oriented restoration”.

The following restoration measures are planned:

(1) Structure Consolidation: the outside RC reinforcement done during 1976-1977 were replaced by new high quality RC, but from inside to restore the historic brick façade finish; reinforcement of entire masonry with

embedded wire mesh and polymer-modified cement plaster

- (2) Installation of new functional rain water down pipe to prevent penetration of rain water into wall
- (3) Installation of new rising damp barrier through pressure-less chemical injection, whose effectiveness has been controlled with help of IR-scanning
- (4) Remove old sealer or painting work by using a paste form paint stripper to restore historic finishing
- (5) Restoration of brick using dentist repair, rebuild and reprofile with restoration brick powder (a kind of repair mortar based on crashed bricks, natural hydraulic limes and additives)
- (6) Re-pointing with lime-based fillers, which matches both in form and in colour
- (7) Impregnation of entire façade with water-borne siloxane especially to joints to improve the rain water tightness.

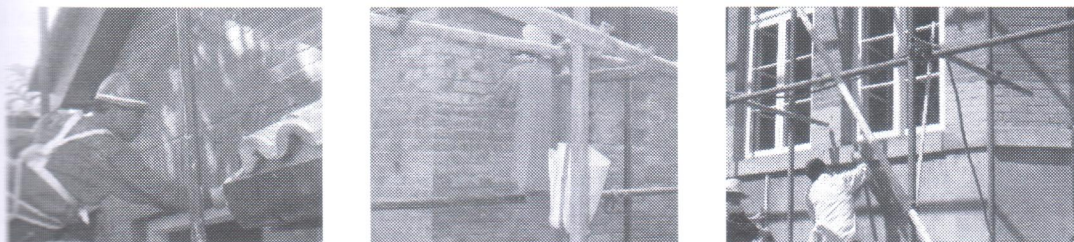


Fig. 6 Façade restoration process (paint stripping, brick repairing & repointing)

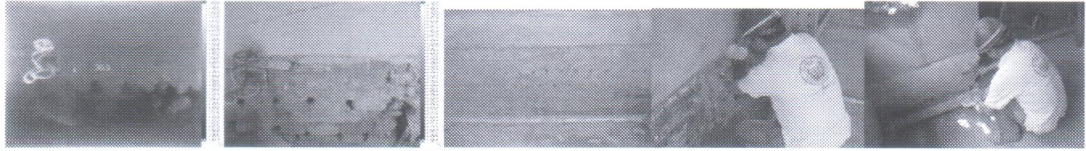


Fig. 7 Investigation, Installation of rising damp barrier through pressureless chemical injection

A few historic buildings in the area of Five Avenues Area (located in Hebei Road, & Hunan Road) have been restored with above mentioned

concept and converted into club houses, studios, luxurious restaurant etc.



Fig. 8 No. 9 of Hunan Road, before (left) and after (right) restoration

4. CONCLUSIONS

Based on the materials analysis, survey of defects and budgeting, the new concept of “new function oriented restoration” has been worked out to restore the unique fair-faced brick façade with controlled costs and compatible to local climate and workmanship.

New research works on the ecological upgrading of historical buildings in Tianjin is ongoing.

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