RGC Ref. No.: UGC/FDS25/E13/16
(please insert ref. above)

RESEARCH GRANTS COUNCIL
COMPETITIVE RESEARCH FUNDING SCHEMES FOR THE LOCAL SELF-FINANCING DEGREE SECTOR

FACULTY DEVELOPMENT SCHEME (FDS)

Completion Report
(for completed projects only)

Submission Deadlines:
1. *Auditor's report with unspent balance, if any: within **six** months of the approved project completion date.*
2. *Completion report: within **12** months of the approved project completion date.*

Part A: The Project and Investigator(s)

1. Project Title

Modelling age composition and survival of high-rise building stock for sustainable urban management

2. Investigator(s) and Academic Department(s) / Unit(s) Involved

Research Team	Name / Post	Unit / Department / Institution
Principal Investigator	LAU Wai-kin/Teaching Fellow	Faculty of Design & Environment (FDE)/THEi
Co-Investigator(s)	LAM Terence CHAN Hon-chuen/Assistant Professor Wu Wing-kin MA Tony/Senior Lecturer	/ FDE/THEi / University of South Australia
Others	-	-

3. Project Duration

	Original	Revised	Date of RGC / Institution Approval *(must be quoted)*
Project Start Date	1 Jan 2017	-	-
Project Completion Date	30 Sep 2018	31 Mar 2019	23 Apr 2018 (approved by Institution)

Duration *(in month)*	21	27	23 Apr 2018
Deadline for Submission of Completion Report	30 Sep 2019	31 Mar 2020	23 Apr 2018

Part B: The Final Report

5. Project Objectives

5.1 Objectives as per original application

1. To review and apply survival analysis methods to model age composition of building stock and predict lifetime and demolition of high-rise buildings in Hong Kong and Adelaide;

2. To identify and establish key factors that affect lifetime and demolition of high-rise buildings in urban environment by collecting and analyzing building data;

3. To identify key factors with which property and facilities managers, building owners and investors can make decisions in the choice of renovation, rehabilitation and redevelopment at micro level when knowledge on building stock dynamics and mortality factors is gained;

4. To collect views and opinions from different stakeholders on various aspects of building stock management; and

5. To suggest policy options to government and provide recommendations to construction, building and real estate industries for sustainable urban management at macro level.

5.2 Revised objectives

Date of approval from the RGC: NA

Reasons for the change: NA

1. NA

2.

3. ....

5.3 Realisation of the objectives
(Maximum 1 page; please state how and to what extent the project objectives have been achieved; give reasons for under-achievements and outline attempts to overcome problems, if any)

For objectives 1 to 3, a database of private buildings in Hong Kong making up of 25,398 occupation permits (OPs) of buildings completed between October 1960 and December 2017 and 11,621 demolition consents (DCs) issued between January 1965 and December 2017 has been built. The data are being processed to (1) determine whether a building is still surviving or has been demolished; (2) classify the records by different building types (i.e. residential, commercial, industrial, or irrelevant if not aforementioned type), location, number of storeys, etc.; and (3) identify buildings that have been demolished and how long these buildings have lasted. Up to the present moment, 14,000 OPs (i.e. those issued between October 1960 and October 1981) have been processed to determine survival and relevance of the buildings. Once the whole data processing exercise is completed, survival analysis and forecasting techniques can be applied to find the mean survival time, age-specific mortality, life expectancy, future completions and demolitions, etc. It is clear that buildings completed October 1960 and December 2017 will be the primary focus, however, collecting OPs and DCs issued between 1950 and 1960 is still targeted. Together with literature and document review on survival analysis methods and key factors that affect lifetime and demolition of buildings and decisions in renovation, rehabilitation and redevelopment, objectives 1 to 3 are largely addressed. Since the research staff left the team in early September 2018 and two Co-Is left THEi respectively in 2018 and 2019, and the challenges facing Hong Kong since mid-2019, the PI is working hard to (i) process the remaining 11,000 OPs; (ii) apply survival analysis techniques to analyse the data once (i) is completed; and (iii) subsequently develop models to predict lifetime and demolition of high-rise buildings in Hong Kong so as to achieve objectives 1 to 3 fully.

For objectives 4 and 5, Policy Delphi workshops are planned to explore policy options to manage existing, aged building stock. The preparation works have largely been done with the format of the workshop decided and the questions to be discussed set. The workshops have not been conducted yet as objectives 1 to 3 are not fully achieved to generate results to be shared with the participants. Processing and analysing OPs and DCs is the "bottleneck" of subsequent research activities. As per the reviewer's comment in the last annual progress report that this project showed potential, the PI is committed to complete the survival analysis and the development of prediction models first before moving on to conduct the Policy Delphi workshop and find the policy options, not to mention disseminating the findings various journal publications.

5.4 Summary of objectives addressed to date

Objectives *(as per 5.1/5.2 above)*	**Addressed** *(please tick)*	**Percentage Achieved** *(please estimate)*
1. *To review and apply survival analysis methods to model age composition of building stock and predict lifetime and demolition of high-rise buildings in Hong Kong and Adelaide*	√	80%
2. *To identify and establish key factors that affect*	√	80%

lifetime and demolition of high-rise buildings in urban environment by collecting and analyzing building data		
3. *To identify key factors with which property and facilities managers, building owners and investors can make decisions in the choice of renovation, rehabilitation and redevelopment at micro level when knowledge on building stock dynamics and mortality factors is gained*	√	70%
4. *To collect views and opinions from different stakeholders on various aspects of building stock management*	√	50%
5. *To suggest policy options to government and provide recommendations to construction, building and real estate industries for sustainable urban management at macro level*	√	30%

6. Research Outcome

6.1 Major findings and research outcome
(Maximum 1 page; please make reference to Part C where necessary)

Although the project objectives have not been fully achieved at the moment, we are very close to obtain meaningful and impactful results.

From the book chapter titled "Measuring high-rise building stock: survival and redevelopment, the case of Hong Kong" reported in Part C, part of the major findings resulted from this project includes:
- Indicators to measure survival and redevelopment of buildings were developed and applied to evaluate survival of Hong Kong's public rental housing blocks and study redevelopment projects of Hong Kong's Urban Renewal Authority. Median survival time (in years), age-specific mortality, life expectancy (in years), intensification indicators (i.e. gross floor area gain (in %)) are examples of the indicators.
- "Syndromes" and trends in the above two cases were revealed using the indicators. The older cohorts of public rental housing blocks built before mid-1970s were found to be short-lived, and the more recent cohorts were expected to last much longer than their design life of 50 years due to the exceptionally low demolition rate; and
- Trends in URA developments were also identified. The redevelopment projects were becoming smaller in scale suggesting that the opportunities for (large) redevelopment become fewer despite the ageing of building stock. Suitable government intervention is necessary and imminent.

From the award winning conference paper "Age composition and survival of public housing stock in Hong Kong" that has been reported in previous annual progress report, the major findings, in short, are:
- the estimated median for the survival time of all public rental housing blocks is 37 years;
- for public rental housing blocks built between 1951 and 1975, the median varied between 29 to 34 years; and
- demolition of public rental housing blocks built after 1975 is rare, due to improvements in construction quality and design quality to provide self-contained rental units.

The above findings are essentially the "public housing version" of the current project. In the course of data processing and preliminary data analysis, private residential buildings are expected to last longer than public rental housing blocks, due to reasons such as better construction quality than their public counterparts in 1960s and 1970s and strata title of private buildings making redevelopment difficult. Though in some cases private buildings survived for 20 to 30 years only, demolition of private buildings completed in mid-1970s is uncommon. As previously mentioned, this project is an impactful one in the time of ageing of building stock and the PI is committed to complete the survival analysis and the development of prediction models.

6.2 Potential for further development of the research and the proposed course of action *(Maximum half a page)*

The ageing of building stock is happening and inevitable in Hong Kong and other more developed cities. To address the ageing problem, rehabilitation and maintenance is far more sustainable than demolition. That said, the lack of funds and malpractice have been barriers to timely maintenance and rehabilitation. Having survival of buildings studied and predicted in the current project, prediction of building rehabilitation costs and examination the pricing strategies of building rehabilitation projects (to crack down on the malpractice) should follow to facilitate rehabilitation in Hong Kong's ageing building stock, particularly in high-rise apartment buildings, so as to slow down the pace of urban decay and create a more sustainable built environment.

The economic life of buildings is another area to study further. Nowadays many local mortgagees no longer assume the lifetime of residential properties to be 50 years but 75 years. Completed in late 1960s, Mei Foo Sun Chuen is now reaching the age of 50 years. While the physical life of reinforced concrete and other building materials have been studied extensively, how mortgagees see building age in financing property purchase and how building age affects volatility of buildings are examples of questions relating to the economic life of buildings to be investigated further.

7. Layman's Summary

(Describe <u>in layman's language</u> the nature, significance and value of the research project, in no more than 200 words)

The ageing of building stock in Hong Kong is confirmed in this project. Residential buildings, among the types of buildings studied in this project, have the highest mean survival time and the lowest demolition rate. They in general have a higher chance of longer survival and less likely to become obsolete, though some in urban areas were converted to other uses such as hotel. Inevitably, we have to live in older buildings in future and young aged residential buildings will only represent a small portion of the total stock. Commercial and office buildings comparatively last shorter than residential buildings, and quite some of them were demolished and redeveloped in their 30s and 40s. Because of the change in economic structure, some industrial buildings built in 1960s were redeveloped in 1970s and early 1980s to build bigger multi-storey industrial buildings. A considerable number of industrial buildings were demolished in recent years and redeveloped to office buildings even they survived the time when the manufacturing sector expanded in 1970s and early 1980s. The findings of this project also suggested that economic and functional obsolesce, not physical deterioration, are the key drivers behind demolition of buildings.

Part C: Research Output

8. Peer-Reviewed Journal Publication(s) Arising Directly From This Research Project

(Please attach a copy of the publication and/or the letter of acceptance if not yet submitted in the previous progress report(s). All listed publications must acknowledge RGC's funding support by quoting the specific grant reference.)

The Latest Status of Publications				**Author(s)** *(denote the corresponding author with an asterisk*)*	**Title and Journal / Book** *(with the volume, pages and other necessary publishing details specified)*	**Submitted to RGC** *(indicate the year ending of the relevant progress report)*	**Attached to this Report** *(Yes or No)*	**Acknowledged the Support of RGC** *(Yes or No)*	**Accessible from the Institutional Repository** *(Yes or No)*
Year of Publication	**Year of Acceptance** *(For paper accepted but not yet published)*	**Under Review**	**Under Preparation** *(optional)*						
2019	-	-	-	Lau, W. K*. and Yau, Y.	*Measuring high-rise building stock: survival and redevelopment, the case of Hong Kong*, in S. Gruneberg (ed.) Global Construction Data, pp. 63-84.	No	Yes	Yes	Yes
			√	Lau, W. K.*, Ho, K. M. K., Lam, T. Y. M., Chan, H. C. K., Tony, M. and Wu, W. K.	Age composition and survival of public housing in Hong Kong: Part I – analysis of 1951-2016 stock. *Building Research & Information*	No	No	Yes	No
			√	Lau, W. K.*, Yau, Y. and Ho, D. C. W.	Age composition and survival of public housing stock in Hong Kong: Part II – forecasting survival of future stock. *Building Research & Information*	No	No	Yes	No
			√	Lau, W. K.* and Yau, Y.	Predicting life span of residential buildings and investigatin	No	No	Yes	No

					g factors that affect their survival. *Habitat International*				
			√	Lau, W. K.*, Yau, Y. and Yau, Y. W.	Discovering high-rise buildings' "Achilles heel": a review and evaluation of quasi-governmental and private redevelopment projects in Hong Kong. *Habitat International*	No	No	Yes	No

9. Recognized International Conference(s) In Which Paper(s) Related To This Research Project Was / Were Delivered
(Please attach a copy of each conference abstract)

Month / Year / Place	**Title**	**Conference Name**	**Submitted to RGC** *(indicate the year ending of the relevant progress report)*	**Attached to this Report** *(Yes or No)*	**Acknowledged the Support of RGC** *(Yes or No)*	**Accessible from the Institutional Repository** *(Yes or No)*
Dec 2018, U.K.	Discovering high-rise buildings' "Achilles heel": a review and evaluation of Urban Renewal Authority's redevelopment projects	1st International Conference on Construction Futures (by University of Wolverhampton)	Yes	No	Yes	No
Sep 2017, U.K.	Age composition and survival of public housing stock in Hong Kong	International Research Conference 2017 (by University of Salford)	Yes	No	Yes	No

10. Whether Research Experience And New Knowledge Has Been Transferred / Has Contributed To Teaching And Learning
(Please elaborate)

- The PI is the subject lecturer of DSU5307 Graduation Project 1: Research Proposal and supervises graduation project works of students. The research experience did contribute to

teaching and learning as the PI used quite some examples from the project when he taught research proposal module. The new knowledge has also contributed to other learning modules such as Conversion and Adaptation of Buildings in which building obsolescence and factors affecting lifespan of buildings were discussed.

- A THEi research seminar titled "Discovering "Achilles heel" of high-rise buildings: an investigation of Urban Renewal Authority (URA) redevelopments" was held on 25 October 2019 to share part of the project findings.

11. Student(s) Trained

(Please attach a copy of the title page of the thesis)

Name	Degree Registered for	Date of Registration	Date of Thesis Submission / Graduation
	Environmental Engineering and Management	Sep 2012	Jun 2017
	Civil Engineering	Sep 2014	Jun 2018
	Civil Engineering	Sep 2014	Jun 2018
	Civil Engineering	Sep 2014	Jun 2018

12. Other Impact

(e.g. award of patents or prizes, collaboration with other research institutions, technology transfer, teaching enhancement, etc.)

- Taylor & Francis Group Award for the conference paper "Age composition and survival of public housing stock in Hong Kong" (Sep 2017).

13. Statistics on Research Outputs

	Peer-reviewed Journal Publications	Conference Papers	Scholarly Books, Monographs and Chapters	Patents Awarded	Other Research Outputs (please specify)	
No. of outputs	0	2	1	0	Type	No.

arising directly from this research project					NA	

14. Public Access Of Completion Report

(Please specify the information, if any, that cannot be provided for public access and give the reasons.)

Information that Cannot Be Provided for Public Access	**Reasons**
NA	