WEIGHTINGS OF DECISION-MAKING CRITERIA FOR THE MAINTENANCE OF MULTI-STOREY RESIDENTIAL BUILDINGS IN HONG KONG

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Abstract

In many well-developed cities, residential buildings in old city centres are deteriorating very quickly. Hong Kong is of no exception because urban decay has long drawn great concerns of the society in Hong Kong. The majority of residential buildings are high-rise and multi-storey. In these buildings, a large number of homeowners are involved in the maintenance of the communal elements in the buildings, and difficulties in balancing the interests of different stakeholders in deciding on the way forward for a maintenance project are common. In this light, it is interesting to study what the decision-making criteria are for the maintenance of different multi-storey residential buildings in the city.

Through literature review, a set of decision-making criteria were sorted out. The criteria were then organized in a hierarchical structure. Based on the data obtained from a pilot study, the weightings or relative importance of these criteria perceived by 56 homeowners in the Western District, Hong Kong were evaluated using a non-structural fuzzy decision support system. The analysis results showed that cost affordability of the maintenance work and existing conditions of the building generally dominated the decision making process. Yet, people living in buildings with fewer flats put greater weights onto people-related decision factors (e.g. expected duration for the household to hold the property and social cohesiveness), compared with those living in larger-scale buildings. These findings implied that people's perceptions towards the relative importance of the decision-making criteria for housing maintenance changed with the characteristics of their places of residence. Practical implications for public administrators in formulating the strategies to promote housing maintenance then follow.

[263 words]

Keywords: Multi-family housing; housing maintenance; multi-criteria decision making; non-structural fuzzy decision support system; Hong Kong.

INTRODUCTION

The built environment of Hong Kong has been praised for its modernity and high-rise high-density setting. However, when one walks through old districts in the city, he or she will find heaps of dilapidated buildings. Similar to other well-developed cities, Hong Kong has long suffered from a serious problem of urban decay. Quite a number of studies (e.g. Ho *et al.*, 2006; Wong *et al.*, 2006; Yiu, 2007; Yau, 2008) have highlighted the problem. While the Hong Kong Government and some public organizations (e.g. the Urban Renewal

Authority and Hong Kong Housing Society) have paid enormous efforts in redeveloping derelict buildings in the territory, the popularity of redevelopment as a means to tackle urban decay is diminishing. As a global trend, sustainable development is put on the top of policy agendas for development in almost every part of the world. Careful upkeep and maintenance of buildings is now regarded as a more sustainable approach to the problem of building dilapidation, at least socially and environmentally.

Although proper building care has gained its importance in the community of Hong Kong, organization and execution of maintenance works are never straightforward, particularly in private buildings with multiple owners. The scattering of rights and responsibilities in buildings of this type creates hurdles in the initiation and coordination of many building maintenance works, especially those in the common areas of the buildings. Maintenance works are often hindered by the failure to achieve consensus among the interested parties. This is largely attributed to the facts that building maintenance always involves multiple-criteria decision making (MCDM), and that each party may have his or her own perceived relative importance of the decision criteria. Against this background, this pilot study explores what decision criteria for building maintenance are perceived as the most important by the residents of multi-storey residential buildings in Hong Kong. This study is somehow a response to the call by Kohler and Hassler (2002) and Augenbroe and Park (2005) for more research on the sustainable management of the building stock. The findings of the study could have significant policy and practical implications. For example, the perceived weightings of the maintenance decision criteria found can offer the local public administrators valuable insights into prioritization of the ways to motivate the homeowners to carry out maintenance works in their buildings.

In this paper, the current situation of building dilapidation and disrepair in Hong Kong will be first overviewed. Afterwards, a MCDM framework for homeowners to decide their participation in building maintenance will be developed. Next, the relative importance of the decision criteria will be explored. The results will be presented and discussed before the paper is concluded.

HOUSING DILAPIDATION AND HOUSING MAINTENANCE

Importance of Housing Maintenance

Housing maintenance generally means upkeep and repair of the building fabrics (e.g. reinforced concrete structures and windows) and services (e.g. water supply systems and elevators) to make the dwellings serviceable. The significance of housing maintenance is multi-faceted. First, housing maintenance helps uphold liveability of the dwellings which has been considered as an imperative determinant of the quality of life (Boelhouwer, 2002; Omuta, 2004). As far as liveability is concerned, the place of residence must be safe and hygienic. Otherwise, the residents are susceptible to various safety and health risks. In fact, the linkage between the quality of the living built environment and human health-being has been well-documented (e.g. Hopton and Hunt, 1996; Waters, 2001; Smith *et al.*, 2003). Neglect of this epidemiological connection by the public administrators, urban managers, building professionals and even residents in compact ‘mega-cities’ like New York, London, Tokyo, Beijing, Shanghai and Hong Kong can be too costly. In a densely-populated built environment, any building failure can lead to catastrophic consequences. This thought was vividly illustrated by the local widespread of the Severe Acute Respiratory Syndrome (SARS) in Amoy Gardens in 2003 because of the illegal alterations and poor conditions of

the drainage systems (Tilgner *et al.*, 2003). In this regard, proper maintenance can help improve the quality of housing, and thus protect people's health-being.

From the economic viewpoint, housing is a capital asset. Like other capital assets such as machinery and vehicles, housing depreciates over time. Proper maintenance can help arrest housing depreciation although it cannot completely counteract the effects of aging (Sweeney, 1974). Without appropriate maintenance, housing will deteriorate quite rapidly (Margolis, 1981). Knight and Sirmans (1996) empirically found that poorly-maintained properties depreciated much faster than those well-maintained. Similar results were also presented by Reschovsky (1992) and Wilhelmsson (2004). Yiu (2007) highlighted the connotation of building maintenance with sustainable economic development of a city. In his study on a large-scale housing estate in Hong Kong, he found that about 45 percent of the asset value depreciated about 40 years, and thus suggested that housing maintenance is of paramount importance to preserve the value of the housing stock. From another angle, housing maintenance can be regarded as "part of a broader process of housing quality change" (Spivack, 1991: 640). It has significant implications on the size and quality of the national housing stock (Reschovsky, 1992).

Apart from its importance to human health-being and economic sustainability, housing maintenance is essential from the social and environmental perspectives. Comprehensive redevelopment can get rid of the urban sores but it also unavoidably displaces the original residents, and thus destroys the local social networks (Jacobs, 1961). The disadvantaged (e.g. low-incomers and ethnical minorities) and businesses were often expulsed from the redevelopment areas (Rothenbery, 1969; Thomas, 1977), resulting in homelessness and unemployment. Furthermore, redevelopment projects create a large volume of construction and demolition wastes. Proper housing maintenance helps prolong the life spans of the housing structures and delay redevelopment need, which is favourable in terms of social and environmental friendliness.

Building Problems in Hong Kong

One of the major impetuses for the study is the recent spate of building-related incidents in Hong Kong. Yau (2008) associated these incidents with the long-standing problem of building dilapidation and disrepair in the city. As at May 2009, there were around 39,000 private buildings in Hong Kong (Home Affairs Department, 2009). The Housing, Planning and Lands Bureau (2005) estimated that about one-third of the private buildings in Hong Kong were over 30 years' old, and the number would reach 22,000 in ten years' time. In addition, the Home Affairs Department's (2009) database indicated that about 10,500 private buildings (26.9 percent) did not have any form of building management. Generally speaking, those old unmanaged buildings are most vulnerable to dereliction and decay. This view has been vividly evidenced by the large number of complaints about the dangers from buildings and accidents involving building structures in the past decade. As indicated in Table 1, although the number of complaints about building dangers peaked in 2005, it was increasing at an average annual rate of 8.5 percent per annum over a twelve-year starting from 1997. The building dangers did not just end as threats but they also result in casualties. According to the report by the Task Force on Building Safety and Preventive Maintenance (2001), 101 deaths and 435 injuries were resulted from building-related incidents during the period between 1990 and 2001. In the recent few years, the gravity of the building problem in Hong Kong was exhibited by the fatal incidents of falling building fabrics like

aluminium windows and concrete pieces (Bowring, 2005; Information Services Department, 2005; Lo, 2005; Buildings Department; 2007).

Table 1: Reports received by the Buildings Department about dangers from buildings (Buildings Department, 2001; 2005; 2009)

Year	Dangerous Advertising Signs	Dangerous Buildings	Dangerous Hillsides	Unauthorized Building Works	Total Number of Reports
1997	350	3,658	130	12,427	16,915
1998	250	3,851	53	12,577	16,731
1999	614	4,730	130	16,999	22,473
2000	260	4,280	71	13,911	18,522
2001	178	6,671	41	12,764	19,654
2002	135	5,956	52	21,844	27,987
2003	181	8,665	48	24,870	33,764
2004	303	10,407	146	21,123	32,069
2005	331	13,999	208	25,683	40,221
2006	564	6,758	183	24,861	32,366
2007	322	4,566	128	24,633	29,649
2008	563	5,412	313	24,942	31,230

Perhaps, the lack of proper maintenance of building in Hong Kong can be ascribed to the predominance of multi-storey residential buildings which are held under co-ownership arrangement in the territory. In this ownership system, the owner of a dwelling unit in a multi-storey residential building does not actually "own" the unit. Instead, each owner possesses an undivided share of the whole building (including the land on which the building was built), and holds the building with other owners as tenants-in-common (Nield, 1990). These individual owners have an exclusive right to occupy and use their own units. In essence, they are co-owners of the whole building, including communal parts such as entrance lobby, corridors, staircases, lifts, pumps and drainage downpipes.

In this light, there are significant differences in the management of a single-family house and that of a multi-family residential building, which has been highlighted by Bailey and Robertson (1997). In the latter scenario, the multiple-ownership nature of the building gives rise to the social and financial interlinks among co-owners. The co-owners collectively have the responsibilities to manage the communal areas and facilities. The use, management and maintenance of these communal elements thus necessitate huge efforts in coordination and cooperation among unit owners. Prohibitively high transactions costs are usually incurred in the process, obstructing maintenance of the communal parts of buildings.

Rather than finding ways to reduce the transaction costs in housing management, this study aims to explore the criteria considered by a homeowner in deciding whether he or she participates in the maintenance of the communal parts of his or her building. In particular, to detect which decision criterion matters most is the centre of the study. To avoid confusions, participation in this study means engaging in the maintenance work with financial resources, and maintenance embraces routine upkeep and repairs.

DECISION MAKING FOR HOUSING MAINTENANCE

Factors Affecting Housing Maintenance Decisions

Maintenance behaviour by homeowners has been extensively studied in the literature. Leather *et al.* (1998) attempted to explain housing upkeep behaviour of homeowners from two perspectives, namely motivations and constraints. Motivations can be consumption-driven (e.g. improvement of the level of comfort or safety of the house) or investment-driven (e.g. preservation or enhancement of property value). They are forces pushing the homeowners to carry out maintenance. For example, one who is living in derelict building should have a higher motivation to carry out maintenance to his or her building with a view to the improved in the living environment. On the other hand, constraints (e.g. ability to pay for maintenance) set viable boundary for homeowners' maintenance decisions. As a matter of fact, economic studies such as Sweeney (1974) and Dildine and Massey (1974) suggested that housing maintenance was a result of a homeowner's decision to maximize his or her own profit. Hendershott and Shilling (1982) elaborated that a homeowner's decision to maintain his or her house depends on the present value of the expected future cash flow and the value of the initial equity investment. In other words, the cost of maintenance and the expected future monetary benefits brought about by the maintenance work matter. Skifter Andersen (1998) added that proper maintenance affected a homeowner's economic gain in two ways. First, maintenance boosts the quality of housing. Given that people, in most cases, prefer better built environment for residence, higher rental incomes were returned for a well-maintained dwelling. Second, proper upkeep can prolong the economic life span of the dwelling, and thus more rental incomes can be received from the property in the long run.

Generally speaking, a yearly cost for maintenance which amounts 6-8 percent of the annualized house value is economically justified (Hendershott and Shilling, 1982). Beyond any reasonable doubt, a homeowner chooses to undertake housing maintenance if he or she can financially afford the costs. Therefore, it is sensible for Winger (1973) to empirically identify a positive relationship between a household's income and expenditure for housing maintenance. Stewart (2003) also explained housing despair as a result of various reasons, *inter alia* financially incapability of low-incomers and lack of knowledge about the importance of building care. Other than economic gains, the effect of tenure mode on homeowners' maintenance behaviour has also attracted a great deal of interest of the academics. Sweeney (1974) observed that on account of "sense of pride" of the owner-occupiers, owner-occupied housing units tended to be better maintained than rental units. Spivack (1991) opined that owner-occupiers responded more quickly to maintenance and upkeep needs because their own self-interest was at stake.

Apart from the factors aforementioned, building age may also play an important role in housing maintenance decisions. In Chinloy's (1980) study, building age was found a significant variable explaining the variation in housing maintenance expenditures. However, this piece of evidence is not powerful enough to confirm the assertion that a homeowner's propensity to maintain swells with building age. As Thomas (1986) mentioned, the average repair and maintenance costs of housing naturally increase with building age. It may be because the building structures depreciate non-linearly so maintaining an old building is more costly than maintaining a younger one. Yet, when studying households' decisions to move or renovate their houses, Montgomery (1992) did find that building age was a significant factor affecting the likelihood of a household to improve its property. Similarly, Littlewood and Munro (1996) also evidenced that the propensity to maintain increased with

building age. As indicated by these previous studies, building age plays an important role in housing maintenance decision.

Focussing on the slum areas in metro Manila, Struyk and Lynn (1983) discovered that housing upgrading behaviour of a homeowner changed significantly with the security of tenure. In general, the more secure is the tenure, the higher is the probability of a homeowner to upgrade his or her house. Situations alike can be seen in Hong Kong. Owners who expect their buildings to be redeveloped soon tend to have less motivation in participating in housing management, leading to poor management and under-maintenance of the buildings (The Standard, 2005; Wong, 2006). This phenomenon is particularly overt in the areas targeted by the Urban Renewal Authority as the homeowners are waiting for their properties to be acquired by the public authority for redevelopment. They thus do not bother investing in the building upkeep because they expect that their properties will not be held by them for a long period. That is why the Urban Renewal Authority (URA) had to launch the Materials Incentive Scheme to motivate these homeowners to improve their buildings in the URA's target areas.

The empirical study by Werczberger and Ginsberg (1987) on the low-income condominiums in Israel signified a negative relationship between the number of dwellings in a building and the quality of maintenance. According to the speculation by Werczberger and Ginsberg, difficulties in organizing the maintenance work arose when more residents were involved. Echoing with the findings in Werczberger and Ginsberg (1987), Spivack (1991) also found that the number of dwelling units per building had a significant negative impact on residential conditions. He partly attributed this negative association to free-rider problem among residents in allocating maintenance responsibilities.

To solve the said free-rider problem in housing, Bengtsson (1998; 2001) proposed three ways: selective incentive, communitarian and institutional approaches. In the first approach, individuals are motivated to cooperate in housing management (including maintenance) by rewards or threats of punishment. It is somehow a kind of stick-and-carrot approach. Positive recognitions for well-performing buildings or grants offered for improvement in housing management and maintenance lure while legal enforcement and sanctions force the homeowners to carry out maintenance. On the other hand, the communitarian approach relies heavily on the mutual trust of the residents. Before one decides to cooperate, he or she has had confidence in others' cooperation. Therefore, improving the social cohesiveness or enriching social capital in a residential area or development has been thought to have positive impact on housing management (Blackaby; 2004; Werner, 2007). Lastly, institutionalization means that formal rules or statutes are laid down to require and guide the homeowners to cooperate.

In organizing homeowners in a multi-storey building to carry out maintenance works, owners' association may play an important role. Kent *et al.* (2002) established that the formation of an owners' association, like the owners' incorporation in Hong Kong, was essential for the effective management and maintenance of a building. It is because the owners association can serve as a central authority on behalf of all homeowners to coordinate them to take collective actions (Chen and Webster, 2005). Empirical studies like Werczberger and Ginsberg (1987) evidenced that the existence of such organization contributed to the maintenance quality of the common areas in the condominiums. Other factors that may affect a homeowner's decision to participate in housing maintenance include the technical knowledge of the homeowner in maintenance (Stewart *et al.*, 2004) and nuisances or disturbance created by the work.

Multi-criteria Decision Making Framework for Maintenance of Multi-family Housing

In the discussions above, different dimensions of a housing maintenance decision have been clearly presented. Affordability and economic gain are, in many cases, not the only issues concerned by the homeowners most. Physical and social factors should be considered. At this instance, it is rather clear that when making a decision in housing maintenance, one needs to think about issues in different aspects. In other words, rather than looking at a single criterion, housing maintenance decision making normally involves multiple criteria or attributes. Through consolidation and customization of the ideas from the previous studies to fit the very situation in Hong Kong, a 3 x 4 decision criterion matrix, as shown in Figure 1, was formulated for decision making in the maintenance of multi-storey residential buildings by homeowners.

At the top of the decision matrix, it is the decision problem. In this study, the problem is deciding whether to participate in housing maintenance or not. To make a decision, an individual should consider twelve different criteria which are categorized under the headings "People", "Project" and "Property". These three Ps are the major facets of concern by the homeowners in housing maintenance. The descriptions of the decision criteria are detailed in Table 1.

Figure 1: A 3 x 4 decision criterion matrix for housing maintenance

Table 1: Descriptions of the decision criteria

Category	Criterion	Description
People	Tenure Mode	Whether the dwelling unit owned by the respondent in the building concerned is for self-occupation or rental purpose
	Duration of Holding	For how long the respondent will hold the property
	Social Cohesiveness	Whether the respondent knows his or her neighbours well and has mutual trust with each other
	Owners' Association	Whether there exists a homeowners' association in the building concerned
Project	Cost Affordability	Whether the maintenance cost is affordable by the respondent
	Technical Complexity	Whether the respondent understands the scope of maintenance work
	Legal Requirements	Whether the maintenance work concerned is required by laws or statutory orders
	Disturbance to Daily Life	Whether the maintenance work creates nuisances or disturbance to the daily life of the respondent
Property	Existing Conditions	How good (or poor) the respondent regards the existing conditions of the building concerned
	Building Age	How old the building is
	Value or Rental Increment	Whether the maintenance work can generate enhancement in property value or rental for the respondent
	Redevelopment Opportunity	Whether the property has a high potential to be targeted by the Urban Renewal Authority or private developers for redevelopment

METHODOLOGY AND DATA

While the twelve criteria in the decision criterion matrix aforementioned have strong bearing on homeowners' maintenance decisions, individuals may perceive the relative importance of these criteria very differently. This divergence in personal views is perhaps one of the major causes of non-cooperation among homeowners in maintenance of a multi-storey residential building in Hong Kong. In this light, this study aims to investigate which decision criterion is considered the most important by the homeowners, and whether the perceptions towards the weights of the decision criteria vary with certain external factors.

Why the Western District?

For this study, the residents living in Sai Ying Pun and Shek Tong Tsui were sampled. These two areas are located in the north-western part of the Hong Kong Island and they are

the constituency areas in the Central and Western District for the District Council election. The populations of Sai Ying Pun and Shek Tong Tsui were 19,035 and 16,359 respectively, as shown in Table 3. Two reasons for choosing these two districts are twofold. First, the Western District was one of the earliest settlement areas since the start of the British regime in 1841. Since then, the district has been a major residential area for the local Chinese. Second, the variety of residential buildings in the Western District is great. There are various types of residential properties, ranging from aged tenement blocks to new residential towers composited with commercial podiums. This feature offers a high degree of variations in the age and type of building. In this case, the target respondents come from living places with diversified characteristics so biases of the residents due to a high concentration of respondents in a particular type of living environment can be minimized.

Table 3: Demographic characteristics of the target areas as at 2006 (Census and Statistics Department, 2007)

	Sai Ying Pun	Shek Tong Tsui	Central and Western District	Hong Kong Overall
Population	19,035	16,359	250,064	6,864,346
Portion of population aged below 15	9.7%	11.9%	12.5%	13.7%
Portion of population aged 15 - 64	70.8%	74.8%	75.1%	73.9%
Portion of population aged above 65	19.5%	13.4%	12.4%	12.4%
Median age	43	40	39	39
Labour force	9,929	8,808	141,522	3,572,384
Median monthly income from the main employment of the working population (HK$)	10,000	10,000	12,500	10,000
Number of residential households	6,448	6,076	88,088	2,226,546
Average residential household size	2.7	2.7	2.7	3.0
Median monthly residential household income (HK$)	15,500	17,000	26,250	17,250
Portion of owner-occupier households	63%	72%	61.9%	52.8%

Weight Determination for Decision Criteria

There are different approaches to determine the weightings for the decision criteria in Figure 1. Undoubtedly, the simplest method is direct allocation of the weight to each of the criteria by decision-makers or external experts. For its simplicity, this approach is easily understandable even by laypersons. However, direct weighing is always criticized for the inconsistent results generated, especially when a large number of criteria or attributes are involved in each weight determination exercise. Given that there are twelve criteria in the decision-making framework developed in this study, it could be difficult, if not impossible, for the decision maker to give a set of consistent weightings to individual criteria using direct weighing. In the other extreme, a highly consistent set of criterion weights can be obtained using the multi-attribute utility model (MAUM). This decision tool was developed based on the studies by von Neumann and Morgenstern (1947), and it deals explicitly with the uncertainty among and interdependence between numerous attributes. Shen *et al.* (1998) opined that the MAUM can minimize subjectivity in weight determination and enhance

transparency. Nevertheless, the weight determination process by the MAUM is very knotty to operate even in its simplest version, and thus is extremely time-consuming and costly. In addition, the application of the MAUM is greatly limited to small group of specialists because of the essential use of advanced mathematical techniques.

For its high practicability and creditability, therefore, the non-structural fuzzy decision support system (NSFDSS) was employed in this study to determine the relative importance or weights of the decision criteria. This method is much easier to operate compared with the MAUM but it can still ensure consistent results to be obtained. The work flow of the NSFDSS is illustrated in Figure 2. After identification of the problem (i.e. whether to participate in the maintenance of a multi-storey residential building or not), the problem is splintered into a number of decision elements or criteria. To facilitate the subsequent pair-wise comparisons, these decision criteria are grouped and arranged in a hierarchy, as shown in Figure 1. One of the major attractions of this hierarchical presentation is that the weighing exercise can be done level by level, with fewer decision elements for comparison each time. In the exercise of pair-wise comparison, each pair of decision criteria under the same category or each pair of categories are compared with reference to their relative importance to the decision problem.

The pair-wise comparisons can be aided with the use of the input matrix in Table 2. The respondents can choose one out of the three output values, namely 0, 0.5 and 1, for each pair-wise comparison. For example, when *Criterion A* (the column element) is perceived more important than *Criterion C* (the row element), an output value of 1 is assigned. A value of 0 is assigned when *Criterion C* is perceived less important than *Criterion D*. When *Criterion A* and *Criterion B* are perceived equally important, a value of 0.5 is assigned.

Table 2: An example of input matrix for pair-wise comparison

Element	Input Value			
	Criterion A	*Criterion B*	*Criterion C*	*Criterion D*
Criterion A	0.5	0.5	1	1
Criterion B	-	0.5	1	1
Criterion C	-	-	0.5	0
Criterion D	-	-	-	0.5

With the completed input matrix, the internal consistency of a respondent's inputs can be checked. As shown in Figure 1, the decision criterion matrix is a 3 x 4 one so the matrices of pair-wise comparisons among decision categories and decision criteria are

$$A\begin{bmatrix} a_{11} & a_{12} & a_{13} \\ a_{21} & a_{22} & a_{23} \\ a_{31} & a_{32} & a_{33} \end{bmatrix} = (a_{ij}) \qquad for \quad \begin{matrix} i = 1,2,3 \\ j = 1,2,3 \end{matrix} \quad , \text{and} \qquad (1)$$

$$B\begin{bmatrix} b_{11} & b_{12} & b_{13} & b_{14} \\ b_{21} & b_{22} & b_{23} & b_{24} \\ b_{31} & b_{32} & b_{33} & b_{34} \\ b_{41} & b_{42} & b_{43} & b_{44} \end{bmatrix} = (b_{mn}) \qquad for \quad \begin{matrix} m = 1,2,3,4 \\ n = 1,2,3,4 \end{matrix} \qquad (2)$$

respectively. a_{ij} is the logical indicator of pair-wise comparison with decision criteria i and j, and b_{mn} for criteria m and n. The pair-wise comparison matrices, which are square matrices, can be completed using the input matrices though the latter comprise only the upper triangle. The lower triangle is obtainable by subtracting each entry in the transposed upper triangle from unity (i.e. one). The internal consistency check is carried out by identifying intransitive cases of (e.g. $b_{12} > b_{13}$ but $b_{23} < b_{24}$). If intransitivity is spotted, the respondent will be requested to revise his or her input values in the input matrix concerned.

What follows the completion of the input matrices is the prioritization of the decision categories and criteria according to the results of pair-wise comparisons. This procedure is illustrated in Table 3. Let's say we are comparing four decision elements under decision category C_y. The values in each row of the input matrix are summed up. The decision elements are then rearranged in descending order of row sum. Following the priority order, a percentile is assigned to each decision element under category C_y. The decision element with top priority (i.e. the element with the highest row sum in Table 3) is assigned with 100 percent, while the remaining elements are compared to it separately to distinguish the relative importance between them. Each percentile is convertible into a semantic score $s_x \in [1, 0.5]$, with 1 denoting not important and 0.5 for same importance, as shown in Table 4. Then, priority score $r_x \in [1,0]$ can be computed from the semantic score by applying fuzzy set theory through the following equation (Tam *et al.*, 2002):

$$r_x = \frac{1 - s_x}{s_x} \quad , \qquad 0.5 \le s_x \le 1 \quad . \qquad (3)$$

Table 3: An example of priority ordering

Element	Input Value				
	Criterion A	*Criterion B*	*Criterion C*	*Criterion D*	Row Sum
Criterion A	0.5	0.5	1	1	3
Criterion B	0.5	0.5	1	1	3
Criterion C	0	0	0.5	0	0.5
Criterion D	0	0	1	0.5	1.5

Afterwards, the priority scores in the same level are normalized to give the localized weights of the decision categories and criteria, as demonstrated in Table 5. Finally, a global weight of a particular decision criterion x under category y can be computed by multiplying the localized weight of criterion x and the localized weight of category y.

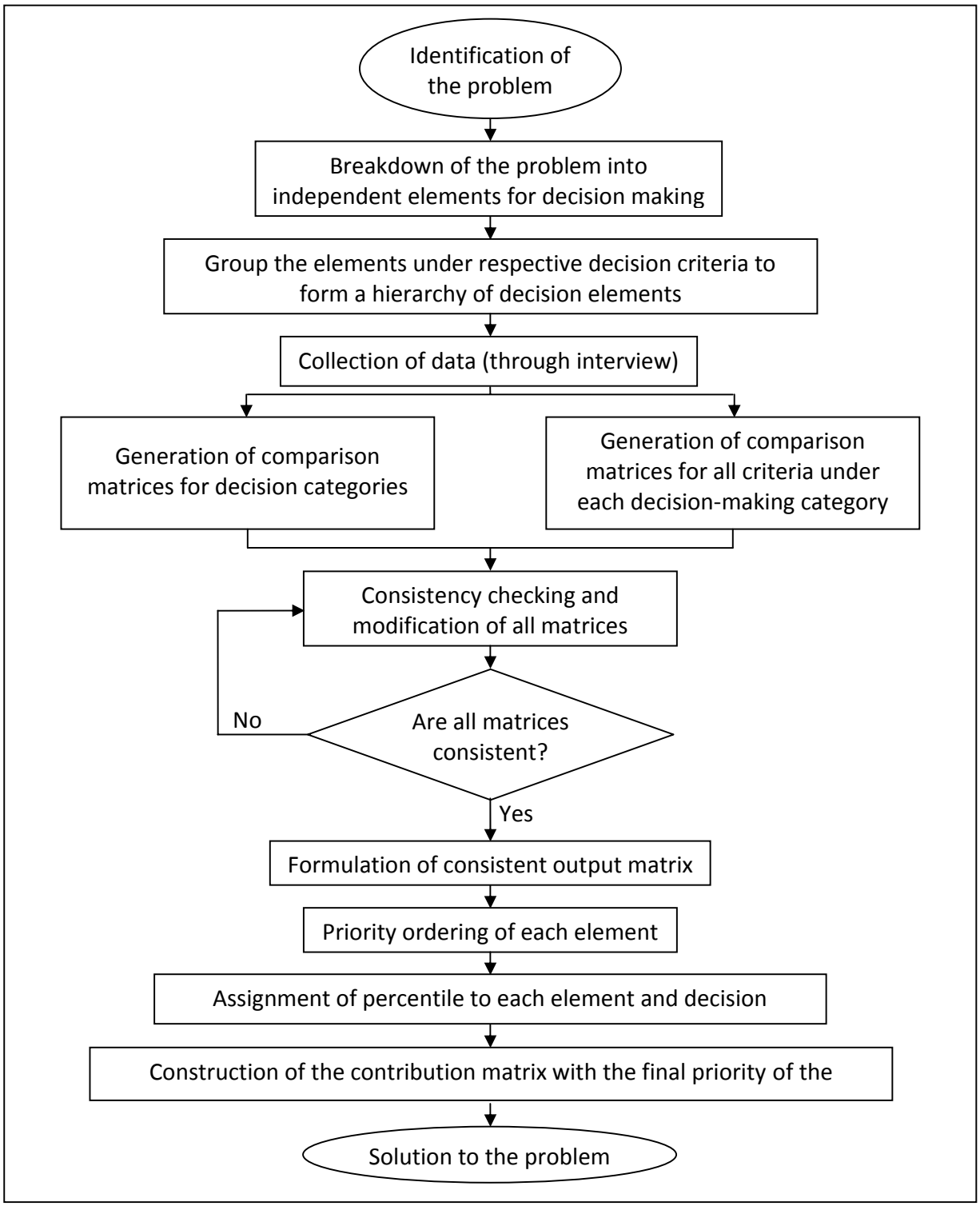

Figure 2: Work flow of the NSFDSS (Ho *et al.*, 2004: 103)

Table 4: Table for conversion between percentile, semantic score and priority score (adapted from Tam *et al.*, 2002: 309)

Percentile (%)	Semantic Operators	Semantic Score, s_x	Priority Score, r_x
100	Same	0.500	1.000
95	In-between	0.525	0.905
90	Marginally different	0.550	0.828
85	In-between	0.575	0.739
80	Slightly different	0.600	0.667
75	In-between	0.625	0.600
70	Quite different	0.650	0.538
65	In-between	0.675	0.491
60	Markedly different	0.700	0.429
55	In-between	0.725	0.379
50	Obviously different	0.750	0.333
45	In-between	0.775	0.290
40	Very different	0.800	0.250
35	In-between	0.825	0.212
30	Significantly different	0.850	0.176
25	In-between	0.875	0.143
20	Very significantly different	0.900	0.111
15	In-between	0.925	0.081
10	Extremely different	0.950	0.053
5	In-between	0.975	0.026
0	Absolutely incomparable	1.000	0.000

Table 5: An example of priority score assignment for calculating localized weightings

Element	Percentile (%)	s_x	r_x	Normalization	Weighting, w_x
Criterion A	100	0.500	1.000	1.000 ÷ 2.540	0.3937
Criterion B	100	0.500	1.000	1.000 ÷ 2.540	0.3937
Criterion D	60	0.700	0.429	0.429 ÷ 2.540	0.1689
Criterion C	20	0.900	0.111	0.111 ÷ 2.540	0.0437
Total			2.540		1.0000

Structured questionnaire survey

To facilitate data collection, a structured questionnaire was used. The questionnaire comprised four parts, including screening question, respondent's particulars, input matrices for priority ordering and percentile assignment. Face-to-face interviews were opted for the opinion survey because it allows the interviewers to explain the terminologies clearly and uniformly to the interviews, and the interviewees to ask questions about the questionnaire to iron out any ambiguities. These procedures are indispensable for ensuring a common understanding of the decision categories and criteria to be weighed by the respondents.

Since homeowners of private housing are the target interviewees in this study, the screening question helps to screen out renters or people with other types of tenure.

SURVEY FINDINGS AND ANALYSES

Findings from the Questionnaire Survey

The questionnaire survey was conducted between 21 March 2009 and 9 April 2009, with a total of 56 face-to-face interviews successfully performed. These respondents came from 17 multi-storey residential buildings in Sai Ying Pun and Shek Tong Tsui. The characteristics of the buildings and respondents are summarized in Tables 6 and 7 respectively. The overall perceived weightings of decision criteria are presented in Figure 3. From the bar chart, one can see that *Cost Affordability* (15.7 percent) was perceived by the 56 respondents as the most important criteria for housing maintenance decision, followed by *Existing Conditions* (14.6 percent) and *Duration of Holding* (11.8 percent). At the other extreme, *Tenure Mode* (4.2 percent) was found to be the least important decision criterion. As far as the category level is concerned, *Project* (35.4 percent) was the most important decision category while *People* being the least (31.5%). However, the differences between the three categories were not significant.

Table 6: Characteristics of the residential buildings accommodating the residents

Characteristics		Number	Percentage
Age			
	10 years old or below	0	0.0%
	11 years old – 20 years old	1	5.9%
	21 years old – 30 years old	11	64.7%
	31 years old – 40 years old	4	23.5%
	41 years old or above	1	5.9%
Number of storeys			
	1 – 10	0	0.0%
	11 – 20	7	41.2%
	21 – 30	10	58.8%
	31 or above	0	0.0%
Number of dwelling units			
	1 – 50	3	17.6%
	51 – 100	4	23.5%
	101 – 150	3	17.6&
	151 – 200	3	17.6&
	200 or above	4	23.5%
Presence of an Owners' Corporation			
	Yes	16	94.1%
	No	1	5.9%
Presence of an external property management agent			
	Yes	13	76.5%
	No	4	23.5%

Table 7: Characteristics of the survey respondents

Characteristics		Number	Percentage
Gender			
	Male	43	76.8%
	Female	13	23.2%
Age			
	25 years old or below	9	16.1%
	26 years old – 35 years old	2	3.6%
	36 years old – 45 years old	21	37.5%
	46 years old – 55 years old	10	17.9%
	56 years old – 65 years old	11	19.6%
	66 years old or above	3	5.4%
Monthly Household Income			
	Below HK$8,000	1	1.8%
	HK$8,000 – HK$9,999	3	5.4%
	HK$10,000 – HK$14,999	10	17.9%
	HK$15,000 – HK$19,999	17	30.4%
	HK$20,000 – HK$24,999	16	28.6%
	HK$25,000 – HK$29,999	6	10.7%
	HK$30,000 or above	3	5.4%
Education Level			
	No schooling / pre-primary	0	0.0%
	Primary	2	3.6%
	Lower secondary	9	16.1%
	Upper secondary and sixth form	24	42.9%
	Post-secondary	21	37.5%

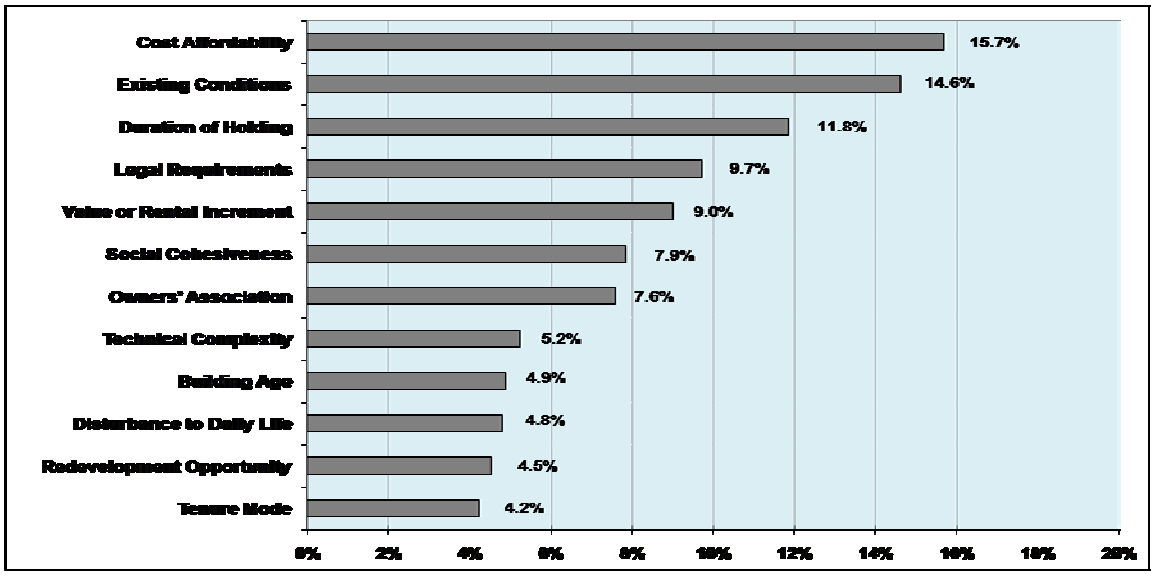

Figure 3: Weightings of the twelve decision criteria for housing maintenance

Comparative Analysis by Building Scale

As discussed in the literature review, previous empirical studies spotted a negative relationship between the number of dwelling units in a building and the quality of maintenance (Werczberger and Ginsberg, 1987; Spivack, 1991). Based on these findings, one may envisage that the homeowners of buildings with different scales may have different weightings for the same decision criterion. This expectation forms the basis for a comparative analysis on the effect of building scale on the perceived relative importance of the maintenance decision criteria. The 17 buildings accommodating the survey respondents were divided into two groups according to their scales: i) with 101 dwelling units or more and ii) with 100 dwelling units or fewer. 33 respondents came from buildings in the first group, with the remaining 23 from buildings in the second group. The relative importance of the decision criteria perceived by the two groups of respondents is paired up in Figure 4.

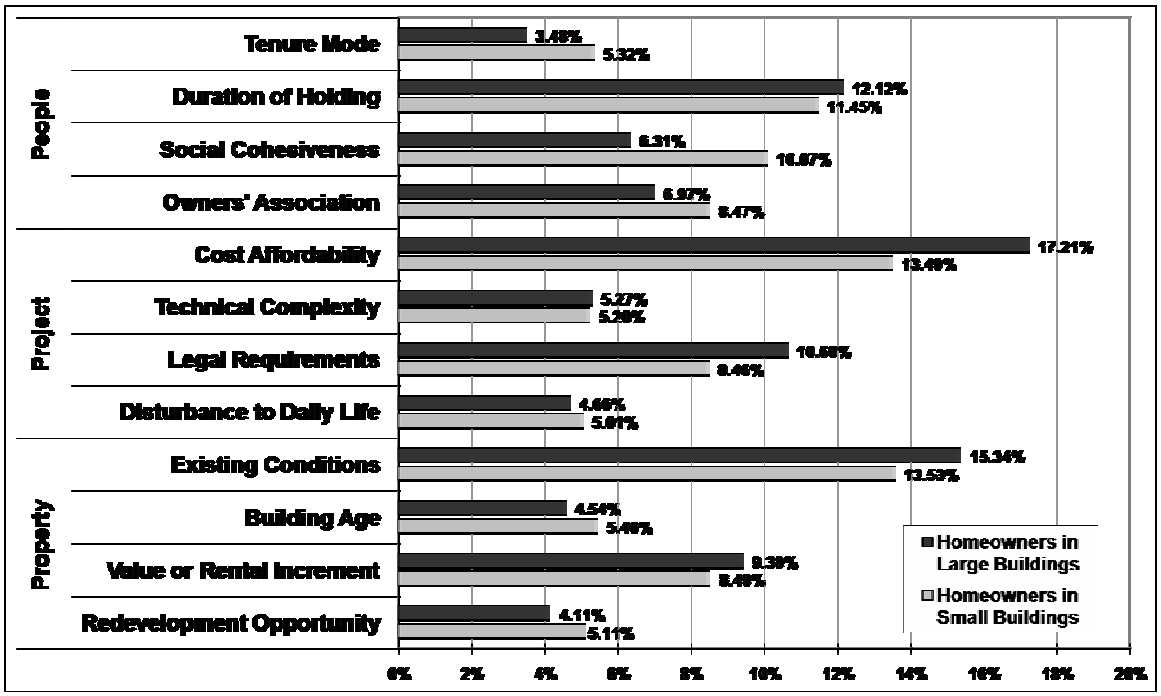

Figure 4: Paired weightings of the twelve decision criteria for housing maintenance

To investigate if the criterion weightings obtainable from the two groups of respondents are similar or not, Spearman's rank correlation test was performed. The twelve decision criteria were ranked according to their relative importance perceived by different groups, and a correlation analysis was conducted on the two sets of rankings. The correlation coefficient returned from the test was 0.70, and the null hypothesis that there was no relationship between the rankings in terms of perceived relative importance of the two sets of decision criteria was rejected at the 1 percent level. Statistically speaking, homeowners living in large buildings (i.e. ones with more than 100 units) weighed the decision making criteria similarly with those living in small buildings (i.e. ones with 100 units or fewer). However, the two groups of respondents perceived quite differently at the category level. For those living in large buildings, *Project* was regarded as the most important category, with *Property* being the second and *People* the third. Oppositely, *People* was considered as the most important by those living in small buildings, with *Project* being the least important.

DISCUSSIONS AND IMPLICATIONS OF THE FINDINGS

It is not astonishing to see *Cost Affordability* and *Existing Conditions* as the most important considerations perceived by the 56 respondents as a whole. Rational homeowners will not engage in maintaining their buildings if they cannot pay for the work. Also, on the account of the direct impacts of poor building conditions on the well-beings of the residents, the actual conditions of the building, compared with building age, played a more imperative role in decision making for housing maintenance. At the same time, using building age as an indicator of maintenance need could result in premature or delayed maintenance. This view is in the same line with the study by Wong *et al.* (2005) who argued that using building age as a yardstick for determining building conditions may lead to inefficiency in public policies.

As for category *Tenure Mode*, it was perceived the least important decision criterion. Perhaps, it is because of the institutional changes in rent control and tenure protection in Hong Kong. Cheung (1975) deduced that landlords would choose to "under-maintain" or "under-repair" their houses in the presence of statutory rent control and tenure protection. Upon the uplift of the statutory rent and eviction controls brought about by the amendment of the Landlord and Tenant (Consolidation) Ordinance (Chapter 7 of *The Laws of Hong Kong*) in late 2002, homeowners should be indifferent in investing in their lived-in properties and rented-out properties. In other words, tenure of the property is no longer a relevant factor in maintenance decision.

These findings bear far-reaching policy implications on housing maintenance and upkeep in Hong Kong. For example, the perceived weightings of the maintenance decision criteria found can offer the local public administrators valuable insights into prioritization of the ways to motivate the homeowners to carry out maintenance works in their buildings. Given that affordability is homeowners' most imperative concern in their participation in the maintenance of the communal parts of a residential building, it is plausible to see the government or other organizations to encourage homeowners to maintain by offering maintenance grants and low-interest loans. This line of thought was supported by the findings of Littlewood and Munro (1996) that grants offered by the state in the U.S. induced the intention of the households, particularly those disadvantaged groups, to carry out maintenance works.

However, as indicated by Table 8, building age, rather than actual building conditions, serves as a screening criterion for the applications for the maintenance and repair subsidies. The findings of this study suggested that the surveyed homeowners did not regard building age as an important criterion in maintenance decision making, compared with existing conditions of the buildings. In this case, people living in derelict buildings with 15-19 years old are likely looking for maintenance opportunities when facing the poor physical conditions of their buildings. The discrimination in building age in the public policies discourages this group of homeowners to carry out timely building maintenance.

Table 8: Loan and Subsidy schemes offered by the public organizations

Scheme	Administrated by	Building Age Requirement
Home Renovation Loan Scheme	Hong Kong Housing Society	20 years old and up
Building Maintenance Incentive Scheme	Hong Kong Housing Society	20 years old and up
Building Rehabilitation Trial Scheme	Urban Renewal Authority	Around 20 years old and up
Building Rehabilitation Loan Scheme	Urban Renewal Authority	Around 20 years old and up

Despite the Spearman's correlation test suggested that homeowners in large and small buildings perceived similarly at the criterion level, different views were obtained in the category level. From Figure 4, it is clear that, compared with those living in large buildings, homeowners in small buildings put greater emphasis on the criterion *Social Cohesiveness*. The reason behind is rather straightforward. Assuming the scope of works is unchanged, maintenance cost shared each household decreases when the building's scale increases as a result of scale economy. Therefore, each homeowner in smaller buildings has to bear a large sum of maintenance cost. If some owners refuse to shoulder their parts, the remaining owners have to share the amount outstanding. In this case, the financial burdens on those contributing homeowners increase vastly. In this light, owners in small buildings tend to think about the nature and characters of their neighbours very carefully when deciding whether to participate in a maintenance project. Certainly, in a building with a high degree of cohesiveness among the owners, mutual understanding and trust helps to foster a cooperative atmosphere, and thus the owners are more willing to participate in housing maintenance. As inspired by these findings, to better promote maintenance in these small buildings, the government should first strengthen the social network in these buildings first. Alternatively, laws or statues should be enacted to penalize those who free-ride the efforts of others.

Besides, the divergent views in the category level implied that a universal set of criterion weights for maintenance decision making (i.e. one applicable to all types of multi-storey residential buildings) might not exist. Nevertheless, the MCDM model developed in this study is not valueless because it can serve as a starting point for further research in the field of study. For instance, studies like Helbers and McDowell (1982) found that elderly households usually under-maintained their dwellings, keeping dwelling characteristics and household income constant. Inspired by these studies, we can explore whether the youth and elderly perceived differently towards relative importance of the maintenance decision criteria using the MCDM model. More importantly, only private homeowners' views were examined in this study, other stakeholders such as public administrators and building professionals have been neglected. It would be interesting to see if homeowners and public administrators perceive similarly. From that study, a negative result could mean a misalignment in the thoughts between homeowners and public administrators, and the findings might be able to explain why the public policies in fostering a culture of building care fail in Hong Kong. Moreover, with minor adaptations, the developed MCDM framework can be used by the homeowners to evaluate different maintenance options.

CONCLUSIONS

With a view to the well-being of the citizens and sustainable development of a city, the health-state of the built environment in the city has to be well-maintained. Despite the fact that Hong Kong is regarded as one of the most vibrant cities in the world, its citizens have long been suffering from the problem of building dilapidation. This building problem is ascribed to a number of different reasons such as the lack of a thorough government policy on building management and maintenance, and weak social cohesiveness. To solve the current predicament in an effective manner, it is necessary for the public authority to know what the homeowners concern when making their decisions in housing maintenance. To this end, this study aims to find out what decision criteria were perceived the most important by the homeowners in making housing maintenance decisions. Based on a survey on 56 homeowners in the Western District, Hong Kong, the perceived relative importance of twelve decision criteria was determined using the NSFDSS technique. The survey findings showed that financial affordability and existing building conditions were the main considerations of the homeowners. Given the ever-growing concerns over the sustainable management of existing building stock (Kohler and Hassler, 2002; Augenbroe and Park, 2005), more attentions should be paid to the research on housing maintenance. This preliminary study serves as a pioneer stimulating more academic research on the decision-making processes in housing maintenance.

ACKNOWLEDGEMENTS

The work described in this paper was supported jointly by a grant the Research Grants Council of the Hong Kong Special Administrative Region, China (Project No. CityU 1508/08) and the Start-up Grant for New Staff from City University of Hong Kong (Project No. 7200123).

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