Assessing the Significance of Mismatching in Buildings' Final Drawings in Dubai Projects

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ABSTRACT

As-built drawings represent the final constructed projects. They are the contract drawings revised during construction and before handing over including all changes. They provide owners and facility managers with a proper reflection of a facility by which the necessary information are used for operation and maintenance processes. They are successfully used in developed industries in the world. This paper is mainly aimed to investigate the significance of buildings' as-built drawings in Dubai through examining the factors that determine their value in terms of availability, accuracy, impact on cost, time and safety. This work will study the significance of mismatches between final drawings and the as-built projects in villas, multi-story and industrial buildings. Technical reports of more than 170 projects were studied in order to analyse and assess the mismatches found at the final inspection for the completion certificate process. The results show 53% of buildings studied had mismatches mainly in external elevations, internal design features and fixtures, specifications, and general works omissions. Improving as-built drawings can be achieved by handling such mismatches earlier in projects' brief and design.

INTRODUCTION

Assessing the significance of mismatches for the construction projects in Dubai by investigating the significance of the as built drawings is the main aim of this effort through which the factors that determine the value of final drawings are examined and analysed. Moreover the mismatch between as-built buildings and final drawings in the handover process is analysed and its significance is assessed. The availability of information about as-built drawings in the literature is limited (Pettee, 2005) and it is about verification and validation the existing as-built drawings, however, this paper is structured by reviewing the literature in brief followed by the research method as well as the analysis and discussion of the results, finally conclusion and recommendations.

Definition of as-built drawings. Various definitions of as-built drawings are agreed tosame concept: the as-built drawings are the original construction drawings revised during construction including all changes; they are prepared by the contractor and reviewed by consultant (Pettee, 2005, AIA best practice, 2007a, As-built Guidance, 2007, and OAA, 2010).Since these documents are used in operations it is essential to add the following statement: "they should have appropriate accuracy, details as well as presentation of the building as it is built". In Dubai the term 'revised drawings' is used to mean as-built drawings. As-built

drawings are mostly inaccurate and do not contain all incurred changes; that is why it is proposed to use the expression ‘final drawing’ instead of as-built.

The factors that determine the value of as-built drawings. As-built drawings are important for contractors during construction and for the clients after completing the project. Also they are essential for facilities manager's needs (Bhatla et al., 2012). In general, they are useful for locating the hidden services and for demolition processes. In addition, they are used as a history of the land-use (Pettee, 2005) and for analysing the performance and planning of corrective action of projects (Hegazy and Abdel-Menem, 2012). In USA, the existing buildings will continue in operation for 20 to 50 years, which ensure the need of as-built drawings (Klein et al. 2012). Finally, as-built drawings provide information useful during the investigation of building's collapse incidents.

In general as-built drawings are inaccurate (Klein et al. 2012) and do not represent the existing buildings (Construction Law Handbook 2007), the reasons are not realizing the value of as-built drawings and the contractors make unauthorized changes without recording to avoid penalty. Details of drawings include locations, sizes, dimensions and material used (Standard Professional Services Guideline 2010). The insufficiencies of as-built drawings are expected to be solved according to Pettee (2005), via educating the different parties to follow the standards for preparing the drawings and incorporating GSM and GPS. The Subsurface Utility Engineering (SUE) is also used to verify the underground services (Jeong et al. 2004). Moreover using3D laser scanning and photogrammetry (Klein et al. 2012), BIM models (Giel and Issa 2011) and the intranet system (Clayton et al. 1998) can give sufficient accuracy. Also shop drawings are complementary to as-built drawings containing more details and handed over to the owners, but no regulations by Authorities are available for approval, they are approved only by consultants, they are mostly inaccurate.

According to Hegazy and Abdel-Menem (2012) using slow information system for producing as-built drawings caused project delay and overrun cost in addition to affect efficiency of operation and maintenance processes (Clayton et al. 1998).The inaccuracy of presenting the concealed MEP services has a serious impact on the construction industry in USA after War II as well as accidents leading to contractual disputes for clients (Jeong et al. 2004). This problem caused wasting $4.8 billion for verifying the existing as-built drawings **(**Klein et al. 2012**)**. And according to As-built guidance (2007) and Pollock (2007) there are thousands miles of concealed cables and pipes in North America have never been documented accurately farther to serious injuries of workers or service's damage during excavation (Building Department, DM 2008). The accurate information will minimize cost and time for operation and maintenance.

According to Guideline for Operations and Maintenance Manuals, (2007) as-built drawings are part of operation and maintenance manual handed over to owner as well as the close out of project (AIA best Practice 2007b). Also they are required to obtain the completion certificate to confirm the works are done to the building regulations (Enfield Council 2012). According to Regulating the Practice of Engineering Consultancy Profession in the Emirate of Dubai, (1999) works on any changes are not allowed to commence until approval has been obtained from Dubai Municipality except minor changes are accepted without revising in final drawings.

RESEARCH METHOD

The section provides justification of the methodology and suitability for use. Two approaches are used for data collection; fieldwork for primary data and deskwork for secondary. The primary data includes the final inspection technical reports collected from Dubai Municipality for almost 172 buildings of three types. The reports contain fresh data used for the first time about mismatches which are not revised in final drawings of civil and drainage works. The secondary data is collected from a literature review including books, journals, papers, researches and websites. The literature did not evaluate the visible mismatches. The methodology of the research is quantitative since nature of gathered data is numerical (Haegeman et al. 2013).

DATA ANALYSIS

The information gathered from technical reports were studied and analysed and the mismatches found in as-built drawings are categorised into changes in elevations, inside buildings, in specifications and missed items (table-1). The buildings are classified into villas, multi-storey and industrial buildings and analysed separately by different ways as Shown in Table 1.

Further to the reasons discussed earlier behind producing inaccurate as-built drawings, there are four reasons A, B, C and D causing mismatches (Fig.1). Reason A is financial related to owners and contractors, B owner's desire, C lack of contractor's experience, relying on incompetent staff, negligence or using wrong ethics to achieve profits and D complexity of design.

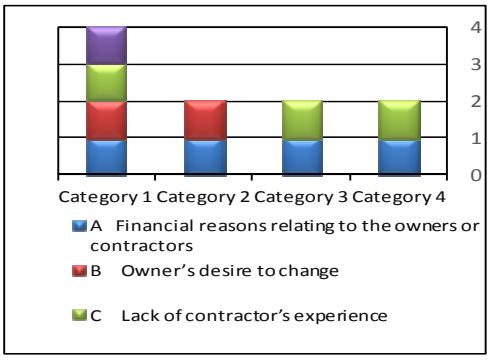


Figure 1. Reasons causing mismatches in projects.
Category ❶ mismatches in elevations
Category ❷ mismatches inside buildings
Category ❸ mismatches in specifications
Category ❹ missed item

Category 1 is caused by reason A, B, C, and D, D causes delay and over cost, therefore changes are done. Category 2 is caused by reason A and B while Category 3 is related to A and C, finally category 4 is due C and A.

Developing significance analysis. Table 2 provides an evaluation of all the categories of mismatches found in the reports. The categories were also identified according to the significance of mismatches

Table 1. Significance score of different categorised mismatches.

Details of categories	significant	%	score
(1) mismatches in elevations			
Cancelling decorative designs at elevations	1	6%	**1**
Changes at elevations			
Changes for the boundary			
(2) mismatches inside building			
Cancelling or adding doors.	1	41%	**3.5**
Changing door's location of bathroom or bedroom.	1		
Shifting of partition.	1		
Changing shape's section columns.			
Cancelling partitions.	1		
Cancelling of store.	1		
Enlargement the area of some rooms.	1		
Raising the floor's level for some rooms.			
Gate level is less than road level.	1		
(3) mismatches in specifications			
Installed sewer or rainwater's diameter is not to specifications.	1	18%	**2**
Using wet manhole instead of dry type inside parking area.	1		
Depth of gully trap is less or more than standards.			
Not using heavy duty covers for manholes.	1		
V.P. height at manhole is low.			
(4) missed items			
Cleaning out (c.o) is not provided at sharing drainage pipes.	1	35%	**3.5**
Strainers for Gully Trap G.T. are not provided			
Floor trap is not provided.	1		
Vent pipes are not done for first manhole.	1		
Expansion joints are not done in roof.	1		
The discharge of rain water at balconies is done free without pipe.			
There is no discharge for rain water at balconies	1		
Drainage of the bathroom is not connected to the manhole.	1		
Pressure breaker chamber of the swimming pool had not been done.			

. **Significance based on type of buildings**. More than 50% of the selected buildings do not match as-built drawings and frequency of mismatches in villas is the highest (Figure 2).

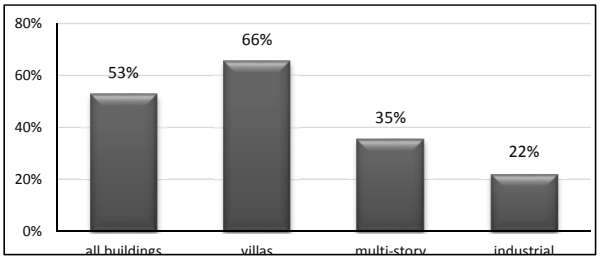


Figure 2. Frequency of Mismatch in different buildings.

Table 2.

category type	significan	insignifican

	t	t
Category 1 (mismatches in elevations):		
Cancelling or adding windows at elevations affects heat insulation efficiency consequently power consumption in building is increased. According to Lyons el at. (1999), heat exchange through window surfaces affects temperature inside building more than other surfaces.	P	
Changing decorative parts in elevations or window's shapes have minor affects.		P
Changes in boundary's decoration do not have impact on the construction		P
Category 2 (mismatches inside building):		
Adding, cancelling or shifting partition for example impact activities such as electrical or drainage.	P	
Raising floor's level of some rooms or changing shape of column's section is mostly done for decorative purposes as per owner's wish, this changes are not affecting another works.		P
Category 3 (mismatches in specifications):		
Light or medium duty cover for manholes impacts safety because covers may be broken.	P	
Installation pipes of diameter less than specifications, will reduce efficiency of drainage.	P	
Changing depth of galley trap affects cleaning process but it is not serious.		P
Using wet manhole instead of dry one at closed areas causes spreading bad odors inside.	P	
Changing height of vent pipe at manhole's connection affect ventilation but is not serious.		P
Changing galley trap's depth affects accessing during maintenance but not serious.		P
Category 4 (missed items):		
Strainers prevents large waste particles (if any) enter inside manholes.		P
Free rainwater discharge from balconies has minor effect sine rains are little in Dubai.		P
Pressure breaker chamber reduce high water before reaching main manhole.		P
Floor trap drains the excess floor water.	P	
Cleaning out (C.O) is necessary for cleaning and maintenance processes.	P	
Vent pipe prevents foul enter inside building.	P	
Connecting bathroom drainage to outside manhole to drain water and sewage.	P	
Not doing expansion joints in roof will cause water leakage.	P	

Table 3 illustrates the significance of mismatching inside all buildings. Villas have high frequency of mismatches in elevations (Fig. 3-b) because of owners' direct interference resulting in continuous changes of the inside of the building. In multi storey buildings there is high frequency of mismatches in the interior of buildings. Finally frequency of mismatches in elevations is high in industrial buildings but mismatches in specifications are significant since they have serious impact on the efficiency of buildings.

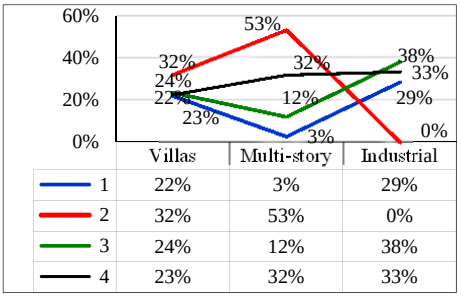
Relationship between frequency of mismatches and built area in villas. Villas are divided based on average area into three groups (Fig. 4).It is found that mismatches in elevations increase when area become larger since more details will be involved as well as owner's intervention. Whereas mismatches in specifications and missed items decrease when area increases; the owners allocate

Table 3. Significance of categories in all buildings.

All building	mismatch categories			
	❶	❷	❸	❹
frequency	41%	20%	24%	15%
significance	41%	71%	48%	51%

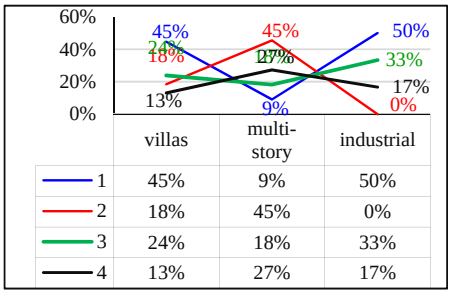
❶ mismatches in elevations
❷ mismatches inside buildings
❸ mismatches in specifications
❹ missed item

a) Significance



	Villas	Multi-story	Industrial
1	22%	3%	29%
2	32%	53%	0%
3	24%	12%	38%
4	23%	32%	33%

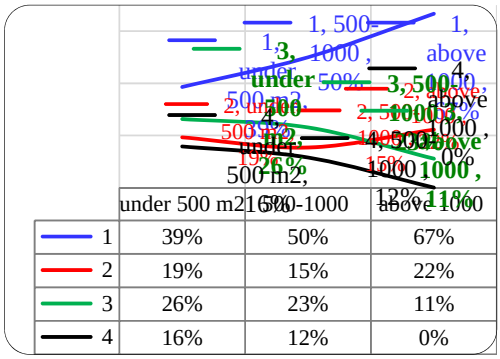
(b) Frequency



	villas	multi-story	industrial
1	45%	9%	50%
2	18%	45%	0%
3	24%	18%	33%
4	13%	27%	17%

❶ mismatches in elevations ❷ mismatches inside buildings
❸ mismatches in specifications ❹ missed item

Figure 3. Significance of mismatches in different buildings



	under 500 m2	500-1000	above 1000
1	39%	50%	67%
2	19%	15%	22%
3	26%	23%	11%
4	16%	12%	0%

❶ mismatches in elevations
❷ mismatches inside buildings
❸ mismatches in specifications
❹ missed item

Figure 4. Relationship between built area and frequency of mismatches in villas

high budget and high specifications for larger villas, so they employ qualified companies who do the work efficiently with minimum changes. Mismatches inside villas are not related to area.

Relationship between frequency of mismatches and number of floors in multi-storey buildings. The frequency of mismatches in elevations and specifications decreases to zero when the number of floors exceed 10 (Figure 5). This may be due to the fact that companies handling buildings that are higher than 10 floors recruit high standard companies to execute their projects.

It is found that no mismatches occur in buildings between 10 and 30 except mismatches inside buildings.

Relationship between frequency of mismatches and area in industrial buildings. It is found that 50% of industrial buildings have mismatches in elevations (Fig. 6). No interior changes occur as most of the buildings are open

spaces having few inside constructions. It is noted that mismatches in specifications

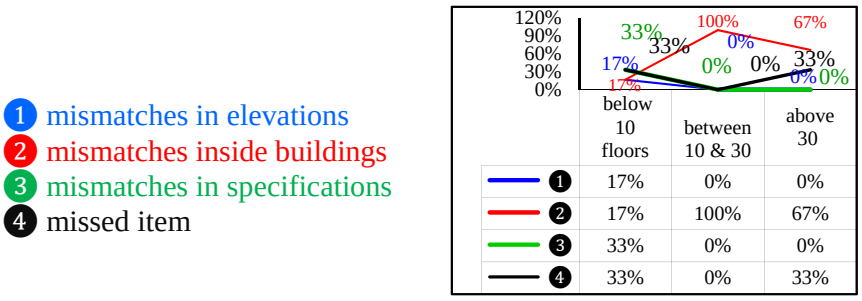


Figure 5. Relationship between the number of floors and frequency of mismatches in multi-storey buildings

increase with larger areas because more details and specifications will raise the cost, so more changes are done accordingly. Finally, missed items decrease in larger areas because of employing qualified companies that execute the works with few errors.

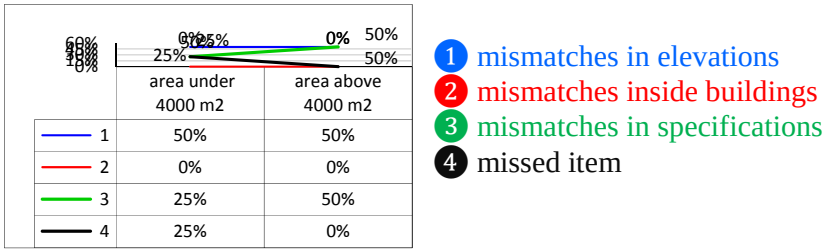


Figure 6. Relationship between built area and frequency of mismatches in industrial buildings.

CONCLUSION

As-built drawings are without doubt important for post construction the phase in all types of buildings. In Dubai, developers are not required to produce the ‘As-Built’ drawings as per the agreed definition proposed in this study. This may be attributed to the lack of awareness on the strategic significance of such drawings and perhaps the need to encourage development of properties by reducing final certificate complications.

There are four main categories of mismatching between planned and completed buildings. These mismatches are in the external elevation, interior of buildings, specifications and finally in omissions. Changes are mainly due to financial issues, lack of contractor’s experience and complexity of design.

Mismatches in villas are more than other buildings and minimal in industrial type. In villas and multi-storey buildings mismatches inside building are significant while mismatches in specifications are significant in industrial buildings. Inaccurate drawings caused additional cost, delay and safety issues for maintenance processes.

The introduction of BIM application in Dubai in November 2013 is a step in the right direction order to eliminate mismatches in future projects.

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