APPLICATION OF BIM IN SUSTAINABLE COMMUNITY MAINTENANCE MANAGEMENT SYSTEM

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ABSTRACT. The task of community management is complex and not easily handled by common residents. According to current statutory regulations, management committees have a term of office; therefore, a multitude of management data and practical experience are not easily passed down. Construction management includes phases of planning, design, commission, construction, and maintenance. This study adopts communities as the subject of study, exploring the current conditions and modes of maintenance management of buildings in Taiwan via documents, and providing integrated recommendations to frequently encountered issues, as well as utilizing BIM environment, ER Studio, database management system, and information technology to develop a "sustainable community management system". This system would efficiently handle the management of the community, keeping a transparent supervision over the financial status, and represent it via the BIM 3D interface, enabling a complete maintenance of community facilities, in order for the community to achieve the ideal of a sustainable management and use. **Keywords:** BIM. Sustainable community maintenance management. Facility manage-

Keywords: BIM, Sustainable community maintenance management, Facility management, Life cycle

1. Introduction.

1.1. **Research background.** In the changing times, the increase in population and modernization resulted in the vertical, large-scale, and complex expansion in size and form of buildings. Their functions and equipment, also due to the demands in providing multiple functions, triggered a demand in services different from the buildings in the past. This includes housing problems such as maintenance and renovation of the facility, residential safety, planning/use of public facilities, and market value of the building. The task of community management is complex and not easily handled by common residents. Additionally, the management committee holds new elections annually, with limited experience and knowledge, various management history data and practical experience are not easily passed down to the succeeding committee [1].

The BIM (Building Information Modeling) is a data integration software with 3D graphs. It enables basic modular technology to fully link up with architectural design database and conduct digital information exchanges during the construction process. One of its features is to be able to create coordinated, uniformed, and computable data for construction projects in design and construction phases [2]. The primary function of BIM in the life cycle of the building is to construct a system with reusable architectural data that can be internally integrated and jointly accessed, which can replace the information and expression in addition to previously inputted data that can be made available for subsequent users, which is helpful in improving project quality, saving time, reducing costs and mistakes [3]. 1.2. Research motivation and objective. In order to reduce the costs for maintenance, as well as maintain the functions of the communities, this study utilizes BIM, SOL, and software development tools to create a sustainable community management system, which assists in the management of daily maintenances in the communities. That information includes all resident data, monthly management fees, parking fees, cleaning fees, security fees, and facility maintenance fees. The BIM environment is used to create an architectural information model of the community, representing important facilities in the community in 3D graphs, which in turn enables maintenance personnel to utilize the convenience of Internet to keep informed with the renovation and maintenance histories of the buildings and facilities. This affords manager efficient control over the maintenance of the buildings and facilities, assisting the management personnel to be better at the task of managing sustainable communities. The research purpose of this study includes:

- A. Through document reviews, the current situation of applying BIM to all industries and areas is compiled, as well as collecting relevant applications and performances related to constructions, and exploring system functions required to be applied on the "sustainable community management system".
- B. ER Studio is used to create the system framework of the "sustainable community management system", complemented by IT to create the interface for a database management system, and integrate BIM to create a management platform for facility maintenances.
- C. Inputting actual cases into the system to authenticate system functions and data transmission accuracy.

The methodology of this study is discussed in Section 2. System development and functions of the community management and maintenance system are discoursed in Section 3. Brief conclusion is dissertated in Section 4.

2. Methodology-Building Management Maintenance Items. In accordance with apartment building management regulations, there is a broad range of layers associated with building management maintenance; hardware includes water/electricity repair, cleaning maintenance, renovation, fire safety; software includes home security, living services, etc. Management service personnel must improve service quality in order to match up market competitions [4]. This study organized community maintenances into the following seven categories:

- A. General administration: including basic information regarding the building, list of residents, list of parking spaces, basic committee member files, contact information on relevant units, etc.
- B. Management fees: including collecting management fees, management fee follow-up reminders, item requisitions/collections, vendor fee payments/collections, regular financial reports, etc.
- C. The periodic use and repair management maintenance of facilities and equipment include the following two categories:
 - a. Security and fire safety: access control management, fire safety equipment inspection/repair statements, building public safety inspection statements, etc.
 - b. Electromechanical equipment maintenance: repair of warranted equipment by manufactures, electromechanical point inspections.
- D. Regular equipment maintenance management: including miscellaneous expenses of environmental cleaning management, security management, water and electricity, and garbage bags.
- E. Community management organization developments: convene management committee conferences, conduct meeting of the unit owners and handle temporary meeting issues, coordinate disputes in the communities, annual community committee management

rights handover, host elections of succeeding committee members, conduct management right transfers, hold resident events, compile community bulletin publications, community management feedback, and self-evaluations.

- F. Annual financial affairs: annual financial reports, financial plans, evaluation and selection of service firms for various management tasks.
- G. Living agency services: including public facility use and management regulations, household services, collect mails/newspapers/milk, call cabs, order airplane/bus tickets, pay water, electricity, natural gas fees and rents, house renovation recommendations, provide life information or creative arts event information, arrange resident get-together events, conduct community family events.

3. System Development and Functions. This study uses the ER Model, database management system, and system development software to construct the database, plan and develop system functions; the data base system is a software system used to create management data. The user can issue database-processing data via the database management system, e.g., append data, update data, delete data, and search data, other than permitting users to access data stored within the database, and allow the data, via internal program designs, to further filter records and conduct logic operations by internal program designs, allowing the user to load the latest information through simple operations.

3.1. System component. This study utilizes system development tool to construct community management system. The system is designed with friendly user window interface. System operating elements' primary function includes:

- A. Data paging, edit and search functions: convenient, easy-to-operate, built-in functions such as: append data, update data, delete data, etc. (as shown in Figure 1)
- B. Drop-down menu data input functions: data is able to be inputted via system default or previously entered parameter setting data with drop-down-and-click functions, skipping the cumbersome work of repetitive typing and data inputting. (as shown in Figure 2)
- C. Drop-down date menu single-click data input functions (as shown in Figure 3)

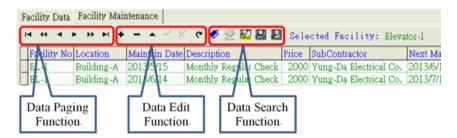


FIGURE 1. Data hot-key buttons

SubContractor	Next Main Date	InCharge	Note
Yung-Da Electrical C 💌	2013/9/16	Jack Lee	Everything is a
Yi-Shin Electrical Inc.			
Da-Yi Water Plumbing	Co.		
Excellent Electricity Co.			
Jia-Jia Electricity Inc.			
King Hydropower Inc.			
Le-Hong Plumbing Co.			
Yung-Da Electrical Co.			

FIGURE 2. Drop-down menu display

F	acility Data	Facility Main	ntenano	ce					
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	Facility No	Location	Mainta	ain Da	ite Des	criptio	n		Price
▶	EL-1	Building-A	2013/	5/15	 Mor 	nthly F	Regular	: Che	2000
	EL-1	Building-A	4		Ma	ay 2013	3		• • •
	EL-1	Building-A	Sun	Mon	Tue	Wed	Thu	Fri	Sat
	EL-1	Building-A	28	29	30	1	2	3	4
	EL-1	Building-A	5	6	7	8	9	10	11 þ
	EL-1	Building-A	12	13 20	14 21	15 22	16 23	17 24	18 25
	EL-1	Building-A	26	20	28	29	23 30	31	īρ
	EL-1	Building-A	2						8 þ
	EL-1	Building-A	S	Today	: 2013/	5/15			ნ

FIGURE 3. Drop-down date menu

Resident Data Maintenance	
House Data House No A01-2 Name Nancy Jwo ID 98274518	
House Add 12F, 707, Wufu Rd., Sec. 2, Hsinchu Copy Add Reset	
Cont Add 12F, 707, Wufu Rd., Sec. 2, Hsinchu Buy Date 2000/2/11 Tel_Home 03-4819217 (F)Group A Area 35.04 Move In Date 2000/2/4 -	
Tel_Office 03-5374287 Ex 6681 (O) Type a3 □ Cable □ Moveln 🔽 Parking	
Tel_Mobile 0910116459 Email nancy_jwo@ms22.hinet.net	
Member Parking Pass Other Lessee Related Fee 1,752 Act House Fee	e 1.752
Park No Plate No Veh Type Own Fee Clear Fee Ark Fee O Act Park Fee O Act Park Fee	0
PLI-050 7127-N3 Car Rent 0 270 ▶PLI-051 3903-KU Car Rent 0 270	540 0
0	0
0	0
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H + + → ▷ ▷ ▷ □ + ▲ - <> <> <>	2,292
Etch Print Save Abort Exit ◄ ◀ ► ➤ ►	

FIGURE 4. Resident data maintenance

3.2. System execution functions. This study has developed powerful system that can be used to administrate community management affairs. Resident data maintenance display is used to manage all information about each resident (Figure 4). Resident payment fetch system can be used to check the payment condition for all residents (Figure 5). When resident paying the management fees, manager can click on the paying months and click "Confirm" button to perform the collection task.

3.3. Facility management. Facility management is an important issue to keep the operation of the community properly. Chen et al. have used QR code to fetch related information for each facility in the building [5]. The author has developed relaxation camp facility management system to assist long-term development of the leisure farms [6]. Usually each type of equipment has different maintenance factories. The system can use subcontractor maintenance function to handle factory data such as subcontractor type (Figure 6) and company data of subcontractors (Figure 7). All subcontractors are grouped and displayed together by subcontractor type. The subcontractors displayed in Figure 7 have the same subcontractor type, "Hydropower", as selected in Figure 6.

All facilities can be easily managed in facility maintenance display (Figure 8). All equipment may have its own maintenance schedule which can be controlled easily through facility maintenance function (Figure 9). All detail maintenance data such as facility name, location, maintenance date, price, description, subcontractor, and next maintenance date, are listed on the system for further query. User can page the facility in this

Resident Pa	yment Fetch S	ystem							
1	A01-2	Na	ncy Jwo	104	Manage	ment Fe	e Payr	nent	jî r
Month	Amount	Paid	Not Paid	This Pay	Chk Item	Penalty	Total	Setup	
Jan	0	₩	*	\oslash	$\langle \rangle$	0	0	Ť	Discount • Yes • No
Feb	0	⋇	*	\oslash		0	0	Ť	
Mar	0	<u>*</u> *	*	\oslash		0	0	Ť	Disc Amount
Apr	0	⋇	*	\oslash		0	0	Ť	Input Pay Number
May	0	⋇	*	\oslash		0	0	Ť	● Yes C No
Jun	2292	☀	*	✓	<u> </u>	0	0	Ø	Bill Number
Jul	2292	☀	*	✓	\Diamond	0	0	Ċ	-Surplus Amount Merge
Aug	2292	*	*	0	\Diamond	0	0	Ť	• Yes C No
Sep	2292	****	* * * * * * * * *	0	<u> </u>	0	0	Ċ	Surplus Amount 0
Oct	2292	*	*	0	<i>\</i>	0	0	Ť	Payment Type
Nov	2292	☀	*	0	\Diamond	0	0	Ċ	• Cash
Dec	2292	*	⋇	0	\Diamond	0	0	Ť	C Check
Acc Owe 1	Total Ann O	we Total	l This Ow	e Amount	House No		🗇 Fe	tch	O Bank Trabsfer
20,08	8 16	5044	458	4	TIOUSE NO	1	<u></u>	1011	C Cash+Check C Postal Transfer
Pay Perce	ent 100	- %, I	Act Pay 4,	584	Year/Month	104 v	05 💌	M	- I Volar Hallolel
Cor	nfirm	Print	合 Rep	orint	Exit Pa	y Date			ate Type Auto 🤆 Manual

FIGURE 5. Resident payment fetching system

💏 SubContractor Maintenance	
SunCont Type SubCont Mai	intenance
SubCont Type Note	<u>^</u>
▶ Air Conditioning	
Electricity	
Elevator	
Fire Control	
Gas	
Generator	
Hydropower	
Network	
Parking Equipment	
Plumbing	~
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FIGURE 6. Subcontractor type table

🚰 SubContractor Maintenance							
SunCont Type SubCont Mai	intenance						
14 44 4 5 55 51 + -	ר י∕ × פי	- 🛷 淤 🌇 🕻	🖌 🛃 SubCo	nt Type: Hydr	opower		
Name	Boss Name	Contact	Phone	Mobile	Fax	Address	1
Excellent Electricity	Yu-Hua Liao	John Wang	03-4253181	0926277586	03-4253183	35, Yi-Chen Rd., Chung-Li, Taoyuan	
King Hydropower Inc.	Ya-Ju Chen	Jack Lin	03-3514586	0986210352	03-3514586	130, Hong-Shin Rd., Sec. 2, Ping-Jen,	1
Da-Yi Water Plumbing	Da-Yi Yang	Mick Hwa	03-4256985	0936215478	03-4256258	25–2, Guan-Lia St., Chung-Li, Taoyuan	
Yung-Da Electrical Co	Wa-Fa Lin	Jia-Hong Li	03-3125478	0975124301	03-3129521	414, Wu-Lin W. Rd., Ping-Jen, Taoyuan	
Le-Hong Plumbing Co.	Le-Hong Chen	Le-Hong Chen	03-2781245	0916021458	03-2780236	23–1, Chung-Shin St., Ping-Chen, Taoyu	I:
▶ Jia-Jia Electricity I:	Jia-Jia Chen	Jia-Jia Chen	03-6214785	0947852140	03-6214502	30, Wu-Fong Rd., Lung-Tan, Taoyuan	
							>
I4 44 4 F FF FF + -		ې 🗞 🎸 🥐	🛿 🛃 Print				

FIGURE 7. Subcontractor maintenance display – Subcontractor maintenance table

Facility Maintenance	×
Facility Data Facility Maintenance	
View Facility	
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Facility Name	~
► Air Conditioning Device	
Broadcasting System	
Cooling Tower	
Elevator-1	
Elevator-2	
Emergency Generator	
Fire Box-01	
Fire Box-02	
Fire Box-03	
Fire Box-04	
Fire Box-05	
Fire Box-06	
Fire Box-07	
Fire Extingguisher-01	
Fire Extingguisher-02	
Fire Extingguisher-03 Fire Extingguisher-04	
Fire Extingguisher-04	
Fire Extingguisher-06	
Firefighting Pump	
Power Receiving Board	
Sprinkler-01	
Sprinkler-02	
	~

FIGURE 8. Facility maintenance display – Facility data table

ility Data	Facility Mai	ntenance						
+ →	► H H +	>	ં ૯ 🛷 💥 🔛 🖾	Selec	ted Facility: Elevate	or-1		
acility No	Location	Maintain Date	Description	Price	SubContractor	Next Main Date	InCharge	Note
L-1	Building-A	2013/7/15	Monthly Regular Check	2000	Yung-Da Electrical Co.	2013/8/15	John Chen	Everything is normal
L-1	Building-A	2013/8/15	Monthly Regular Check	2000	Yung-Da Electrical Co.	2013/9/16	Jack Lee	Everything is normal,
L-1	Building-A	2013/9/16	Annual Regular Check	5000	Yung-Da Electrical Co.	2013/10/15	Jack Lee	Everything is normal
L-1	Building-A	2013/10/15	Monthly Regular Check	2000	Yung-Da Electrical Co.	2013/11/14	Jack Lee	Everything is normal
L-1	Building-A	2013/11/14	Monthly Regular Check	2000	Yung-Da Electrical Co.	2013/12/16	Jack Lee	Everything is normal
L-1	Building-A	2013/12/16	Monthly Regular Check	2000	Yung-Da Electrical Co.	2014/1/15	Jack Lee	Everything is normal
L-1	Building-A	2014/1/15	Monthly Regular Check	2000	Yung-Da Electrical Co.	2014/2/14	Jack Lee	Everything is normal
L-1	Building-A	2014/2/14	Monthly Regular Check	2000	Yung-Da Electrical Co.	2014/3/14	Jack Lee	Everything is normal
L-1	Building-A	2014/3/14	Monthly Regular Check	2000	Yung-Da Electrical Co.	2014/4/15	Yu-Lung Li	Everything is normal
L-1	Building-A	2014/4/15	Monthly Regular Check	2000	Yung-Da Electrical Co.	2014/5/15	Yu-Lung Li	Everything is normal
L-1	Building-A	2014/5/15	Monthly Regular Check	2000	Yung-Da Electrical Co.	2014/6/16	Yu-Lung Li	Everything is normal
L-1	Building-A	2014/6/16	Monthly Regular Check	2000	Yung-Da Electrical Co.	2014/7/15	Yu-Lung Li	Everything is normal
L-1	Building-A	2014/7/15	Monthly Regular Check	2000	Yung-Da Electrical Co.	2014/8/15	Yu-Lung Li	Everything is normal
L-1	Building-A	2014/8/15	Monthly Regular Check	2000	Yung-Da Electrical Co.	2014/9/15	Yu-Lung Li	Everything is normal,
L-1	Building-A	2014/9/15	Annual Regular Check	5000	Yung-Da Electrical Co.	2014/10/15	Yu-Lung Li	Everything is normal
L-1	Building-A	2014/10/15	Monthly Regular Check	2000	Yung-Da Electrical Co.	2014/11/14	Yu-Lung Li	Everything is normal
L-1	Building-A	2014/11/14	Monthly Regular Check	2000	Yung-Da Electrical Co.	2014/12/15	Yu-Lung Li	Everything is normal
L-1	Building-A	2014/12/15	Monthly Regular Check	2000	Yung-Da Electrical Co.	2015/1/15	Yu-Lung Li	Everything is normal
L-1	Building-A	2015/1/15	Monthly Regular Check	2000	Yung-Da Electrical Co.	2015/2/16	Yu-Lung Li	Everything is normal
L-1	Building-A	2015/2/16	Monthly Regular Check	2000	Yung-Da Electrical Co.	2015/3/16	Yu-Lung Li	Everything is normal
L-1	Building-A	2015/3/16	Monthly Regular Check	2000	Yung-Da Electrical Co.	2015/4/15	Yu-Lung Li	Everything is normal
2-1	Building-A	2015/4/15	Monthly Regular Check	2000	Yung-Da Electrical Co.	2015/5/15	Yu-Lung Li	Everything is normal
2-1	Building-A	2015/5/15	Monthly Regular Check	2000	Yung-Da Electrical Co.	2015/6/15	Yu-Lung Li	Everything is normal

FIGURE 9. Facility maintenance display – Facility maintenance table

function to view maintenance history. Figure 9 is the detail maintenance data for facility "Elevator-1".

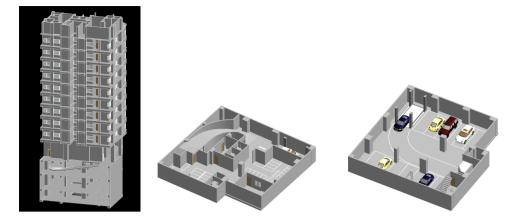


FIGURE 10. 3D views constructed by BIM environment in this study

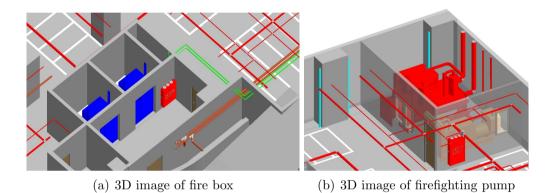


FIGURE 11. 3D images of the selected facility

3.4. **BIM 3D display.** This study used BIM to construct 3D model of the community (Figure 10). Administration staffs can view these 3D displays to easily control office management jobs. In Figure 8, when certain facility is selected and push the "View Facility" button, the 3D image of the selected equipment will be displayed (Figure 11).

4. **Conclusion.** This study aims to improve the maintenance and management efficiency of buildings, provide a standardized management procedure regulation and tool for community organizations with limited experience and knowledge regarding community management issues, reduce unnecessary waste of time, manpower, materials, and avoid mistakes or human-malpractices to improve the quality of use of buildings. Explanations on the contributions of this project are as follows:

- A. Assist regular communities in solving issues of current management committee being unfamiliar with community management tasks; improve the feasibility of selfmanagement by the unit owners; and resolve the issues of management experiences being hard to pass down for the residents and committee, as well as past management records being hard to preserve.
- B. Allow residents to accurately be aware of monthly incomes and expenditures of the community. Software management can avoid human mistakes and possible malpractices.
- C. For residents with arrears in rents, accurately calculate the duration and amount unpaid, and automatically print out reminders, legal attest letters, and warrant of payments. This makes early residents arrear with rents to be brought to daylight, also improve the paying rate of management fees from the residents via the release of the arrears list and supervision of residents.

- D. Avoid unnecessary data entries and complex repeating operations, reduce unnecessary time and costs for document and financial affairs, reduce human errors in traditional operations, and implement the management work and standard procedure.
- E. Able to allow the residents and committee to look up on every management data, and provide management personnel with latest information to solve unexpected problems.
- F. Able to provide management personnel with facility maintenance schedules to ensure normal operations of all facilities, as well as quality and safety of the residents. Via 3D perspective screens, improve the availability of community facility maintenances.
- G. The open and transparent community network management system can reduce the distrust of the residents toward the committee.

The smart phone integrated with QR code is suggested for possible future study to provide a more convenient and powerful tool for mobile version of community management and maintenance tool.

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