BIM-GIS TECHNOLOGIES IN ANALYSING THE COST OF ASSETS AFTER NATURAL DISASTERS: WATER FLOOD AND EARTHQUAKE

Abuov Y., Omirtay O.
Nazarbayev University, Astana

BIM-GIS integration. Analysing the cost of damage of buildings after natural disaster happened is a quite complex process. Methods having now to solve this problem take too many approximations; these models neglect unique parameters of each building. Final cost of damage depends on big number of variables. For example, in case of water flood, those variables can be: 3D geometric parameters of building, unit cost of materials, water velocity, depth of flood, physical properties of material, terrain geometry, etc. There is no single software to run mentioned complex model. This paper suggests integration of Geographic information system (GIS) and Building Information Modeling (B I M) as a method to perform cost analysis after natural disasters happened in given urban place. Both B I M and GIS are software which represent real world in digital format. But B I M uses micro level of objects and handles mainly indoor data while GIS uses macro level which includes rivers, basins and data in outdoor. Also, GIS is more near to 2D dimensional while BTM is 3D dimensional. The modeling of complex building needs environmental analysis and decision making which can be the done by integration of BIM and [1]. This paper will show how BUM's work can be assisted by geospatial data provided by GIS and it could enhance cost analysis of buildings after natural disaster happened. Two cases of natural disasters are considered in this paper: water flood and earthquake.

Methodology. Standard methods used in FDA (Flood Damage Assessment) do not consider building parameters such as geometric parameters, material property, interior part, etc. This is mainly due to absence of good quality data to have accurate and complete estimates for FDA. Amirebrahimi et al. [2] developed the new method for FDA using B1M-G1S integration. Damage assessment is divided into four steps: data preparation, physical damage assessment, communication and analysis. These steps are illustrated in Figure I. Data preparation step includes collection of all inputs that will be used for simulation. Geometric details of buildings as well as their physical properties and unit cost parameters are derived from the B I M model. Tf BTM model is not available, model can be drawn in Autodesk Revit. While finishing with Revit model, next step is collecting flood parameters. For that simulation of flood is needed to obtain two important parameters for flood: distribution of speed and distribution of depth. Flood occurs in given terrain model which is obtained from GIS model with Digital Terrain Model (DTM) points. Elevation is assigned for each point of DTM inside GIS. Flood is simulated in commercial software such as MTKE and TUFLOW. They found to be a good solution in Flood Dynamics for the cases with 3D model obstacles. Physical damage is also considered in method: in this simulation they use method developed by Kelman [3] to calculate physical damage from infiltration of water into house interior. If materials are susceptible to the damage from water are indicated with proper correction factors, this enhances the final result.

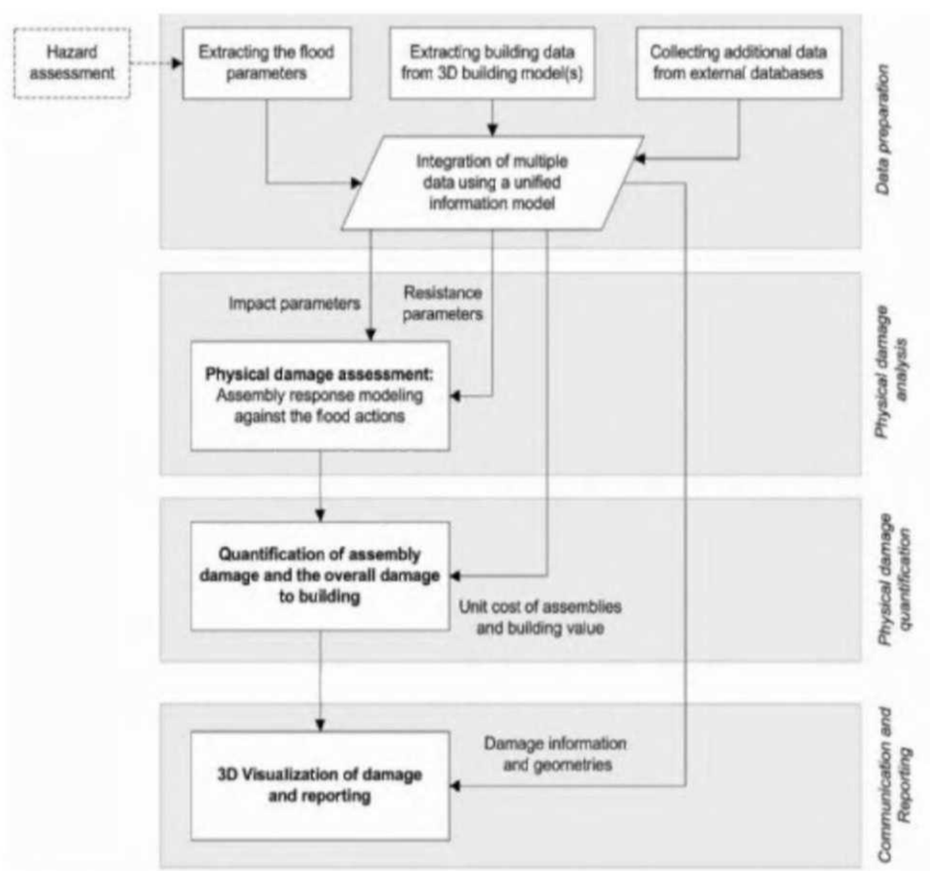

Figure 1. Steps for FDA using BIM-GIS integration method. Source: Amirebrahimi et al. |2|

Force actions due to lateral flood pressure are calculated to check structural stability of building using Finite Element Analysis method. Value of physical damage is calculated based on the degree physical damage. Amirebrahimi et al. [2] refers to the formula developed by Scawthorn et al. [4]; Nadal et al. [5] to calculate cost of physical damage. Level of detail should be the high only on the regions of interest, but too high detailing results the slow simulation run time. At the end of simulation all necessary data is tabulated with final results which is the summation of all costs. In addition, 3D visualization of model after disaster is provided also. Different areas of model indicated with colors depending on degree of physical damage.

Case study 1. Water flood cases (infrastructure planning, flood damage analysis, earthquake). For the case study of Flood Damage, an example is a typical Australian house in the City of Maribyrnong. Highest flood rate in 100 years is taken to simulate the worth case of flood. All 4 steps (Figure 1) mentioned in methodology are performed in the sequence. Figure 2 shows the GIS model where house is located. Ready-to-use BIM model of house was unavailable. However, R E V 1 T model of building was built from given structural and architectural plans. Typical materials such as veneer walls, plasterboard lining, etc. were used; their replacement and repair costs are taken from the Australian Construction Cost Guide [6].

Figure 2. Aerial image and GIS model of terrain where house is located. Source: Amirebrahimi et al. |2|

MIKE 21 hydrodynamic simulation software was employed to simulate flood with 3D obstacles. Hence, flood parameters (flood velocity, flood depth, etc.) were obtained. Area of external BIM (Figure 3) model was converted to Shapefile for use in GIS interface. Figure 3 also shows simulation results of MIKE software which shows distribution flood parameters with time variance.

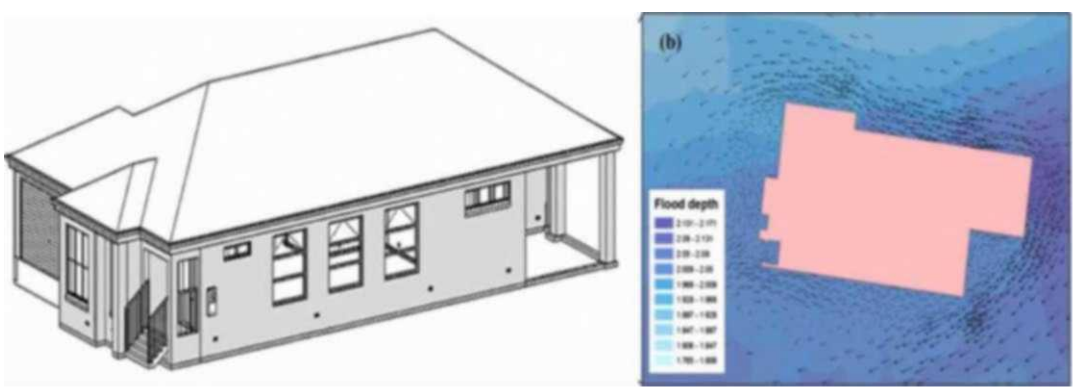

Figure 3. Revit Model of the house and flood simulation in MIKE software. Source: Amirebrahimi et al. |2|

Rest part is the physical damage part which involves the check of structural stability. Main variable of physical damage is flood depth, since it indicates amount of water lateral pressure. Further steps in physical damage analysis is complex, it has more detailed explanation in Amirebrahimi et al. [2] which involves work in ANSYS software, structural analysis tools mentioned in Methodology part and Risk analysis tools. Final tabulated result of this work is shown Table 1.

Tabic 1. Tabulated results of flood damage assessment for case of Australian house. Source: Amirebrahimi et al. |2|

Item	Building components	Type	Count	units	measurement	(AUD$)	(AUD$)
1	Timber-framed highlight window with sliding (25% opening), one operator to open (one sliding sash)	Window	1	1	Each	420.00	420.00
2	A & L aluminum Timber Entry Frame double sidelight (entry door solid core)	Door	1	1	Each	227.00	227.00
3	Hollow-core door (standard 35m thick)	Door	13	13	Each	151.00	1963.00
4	CSD pocket sliding door (single panel)	Door	2	2	Each	211.00	422.00
5	CSD pocket sliding door (double panel)	Door	1	1	Each	305.00	305.00
6	Electric meter box	Electrical	1	1	Each	855.00	855.00
7	Double power point	Electrical	30	30	Each	45.00	1350.00
8	Single lighting switch	Electrical	15	15	Each	24.00	360.00
9	Timber skirting	Joinery	55	137.88	m	15.10	2081.98
10	Ceramic tile skirting	Joinery	21	45.22	m	21.50	972.23
11	Carpet flooring (rubber underlay included)	Flooring	6	77.181	sqm	58.50	4515.08
12	Timber flooring	Flooring	1	101.027	sqm	205.00	20,710.53
13	Wall lining (gypsum wall board)	Lining	82	418.919	sqm	28.50	11,939.19
14	Wall lining (gypsum wall board – water resistant)	Lining	26	93.32	sqm	32.50	3032.90
15	Insulation (rockwool batts for wall timber framing)	Insulation	21	171.56	sqm	13.15	2256.01
					Total damage:		51,409.95

CSD. Central Security Distribution.

Case study 2. Building asset management for earthquake. Similar analysis of damage can be done for an earthquake hazard. Christodoulou et al. [7] suggests BIM, especially ArchiCAD model to predict the damage cost using complex methods such as Assembly-Based Vulnerability (ABV), Pacific Earthquake Engineering Research (PEER) along with structural analysis techniques. First of all, 3D model of a building has to be created in ArchiCad to be able to visualize and analyze the data about building components (both structural and non-structural). Cost results can be performed by BIM information based on structural characteristics of each component with its own criteria for analysis followed by results after simulation.

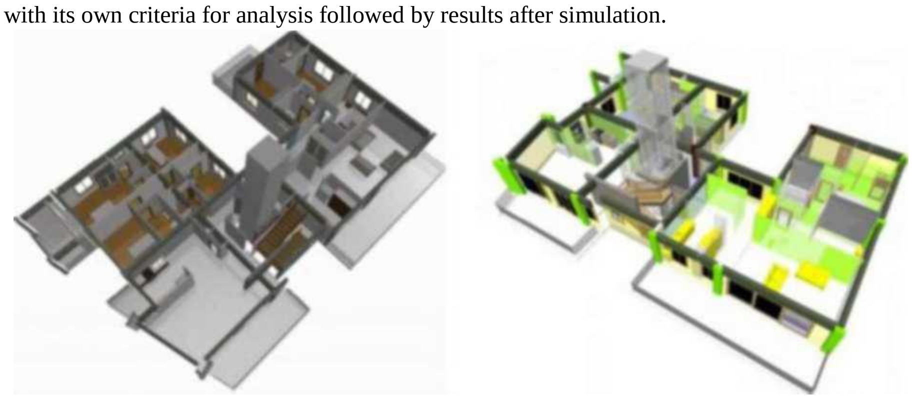

Figure 5. Model in ArchiCAD before and after earthquake simulation. Source: Christodoulou et al. [7]

Figure 5 shows the earthquake simulation on ArchiCAD model; if green colour gets darker (from green-yellow-red-to black) in after simulation picture it means high degree of damage with its recommendations whether it can be repaired or should be replaced. As in Revit model, all division parts of assigned to unit cost of repairing or replacement. Result of earthquake damage simulation gives results in the table similar to table 1; resultant table is not shown here to meet page number limit. As in the case of water flood, this singular model can be linked with GIS, so we can have access to multiple buildings. Therefore, using BIM-GIS integration could be used for the earthquakes also.

Discussion and conclusion. BIM-GIS solutions for the financial assessment of natural disasters were reviewed. Amirebrahimi et al. [2] did the review of 4 conventional methods for damage cost analysis (ex post method, averaging, damage curves and detailed vulnerability assessment) that were used in FDA. According to the review, all those methods require huge amount of data collection and further analysis work to reach good accuracy in estimates. Method of BIM-GIS integration saves time and money. BIM-GIS method analyzes the damage cost using engineering methods: detailed 3D geometry model, flood parameters, Digital Terrain Model (DTM), degree of physical damage to building and unit cost of each element.

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