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Case-driven category analysis of 3D building property

Shen YING, Hanrui SUN, Chengpeng LI, Wenting ZHANG, Meng WANG, Yong ZHAN, Yu ZHANG and Xueye CHEN, China

Key words: 3D cadastre, building property, ground level, earth surface, location, spatial relationship.

SUMMARY

Many immigrants from rural areas pour into urban areas, especially in China, and urban development faces the challenges to provide sufficient space for citizens' acommodation, works and social contacts. So 3D development and use of land and city space become the reality with various complex buildings and constructions with modern architecture and construction techniques. Many underground constructions like mall and subway with stations are built without clear impression comparing to the above reality scenes. Also many buildings above the earth surface show their special characters with either air building / overpass / viadust or "strange" shapes getting our attentions; but actually they bring new challenges of spatial management to handle the 3D property unit, either in describing their relations with reference to earth surface or in performing administrative processes in transactions of planning, approval and management. From the real cases of buildings or 3D property, this paper first details the relations between 3D properties and earth surface, the relative location relations between 3D building properties and earth surface form, and the correspondence between 3D building properties and surface parcel, then classifies the category according to these three profiles, which would promote the understandings of complex buildings and 3D building properties and would enhance the descriptions and the segmentation of 3D building properties.

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1. INTRODUCTION

With 3D utilization of urban land, land administration tends to transform from 2D model to 3D space which is more precise. Modern building and construction technology supported various 3D shapes, and many buildings above the earth surface show their special characters with either air building / overpass / viadust or "strange" shapes getting our attentions. The "parcel" space is divided into different stratas both on the earth surface and above/under the surface and results in multiple strata ownership/usership. Actually, these realistic cases bring new challenges of spatial management and our land administration to handle the 3D property unit, either in describing their relations with reference to earth surface or in performing administrative processes in transactions of planning, approval and management because traditional 2D projection parcel couldn't fit the requirement for clear spatial relationship descriptions. 3D cadastre arises to tailor the new challenges. The cores of 3D cadaster are the descriptions and management of 3D building property.

The State Council of the People's Republic of China issued the document NO.96 to carry out 3D land administration based on core 3D cadastral techniques with the responsibility of Ministry of Natural Resources of People's Republic of China.

Research on 3D cadastre began from the case study (Guo Renzhong et al., 2011; Góźdź et al., 2014). With the case studies, the limitations of 2D cadastre could be clear analysed and corresponding 3D solution project would be framed. 3D property unit is the basic unit in 3D cadastre for 3D land administration and registration (Ying Shen et al.,2018). Research is mostly focused on 3D data structure and data model (Guo Renzhong et al., 2012), topologic reconstruction and maintainance (Ledoux et al., 2011; Li Lin et al., 2012), spatial computation and operations (He biao, 2011) and visualization (Ying shen et al., 2019). Cases and analysis about shape category of 3D cadastre are seldom; only simly classification about 3D cadastral objects is mentioned with division of surface parcel, above-surface parcel and under-surface parcel (Wang Lvhua et al., 2014) or with division of 3D regular shape or 3D irregular shape (Wu Changbin, 2016).

This paper focuses on the realistic cases of 3D building properties and analyses them from morphological aspect. This paper first details the relations between 3D properties and earth surface, the location relations between 3D properties and earth surface form, and the correspondence between 3D properties and earth surface parcel, then classifies the category according to these three profiles, which would promote the understandings of complex buildings and 3D building properties and would enhance the descriptions and the segmentation of 3D building properties and 3D land administration, which would bring about better indeed registration, reducing quarrels and protecting interests.

2. RELATIONS BETWEEN 3D PROPERTY UNIT AND SURFACE BASED ON CASES

Most our behaviors and actions happen on the earth surface, and we have formed the stable understanding about surface reference. When we talk about the buildings, we all knew they are built on the earth surface. Buildings and constructions normally have a plan ground with same surrounding elevation. However, it wasn't always this way. Mountain areas occupy 2/3 land area in China and many buildings and constructions built on unplannar gound, especially in Chongqing City. If we pay our attention on the surface to analyse the buildings, questions are arised: Where is the ground? Is the ground surface same or flat? Buildings in mountain city are built on the slope (Figure 1A), or even the same building connect the surface at different elevations in different directions (Figure 1B). For example, the ground surface of the building in Figure1 in two sides are different. Also, the surfaces among different buildings are curve. Where is the ground level? More amazing, the top of the lower building in Figure 2a is the ground of another higher building; the "current" location is the ground of the skyscraper, at the same time, it is the top of another 28-storey building property. Where is the ground surface for one building property? How to define the the ground surface for SEVERAL group buildings? It is important to make a clear category of the relationship.

A **B**

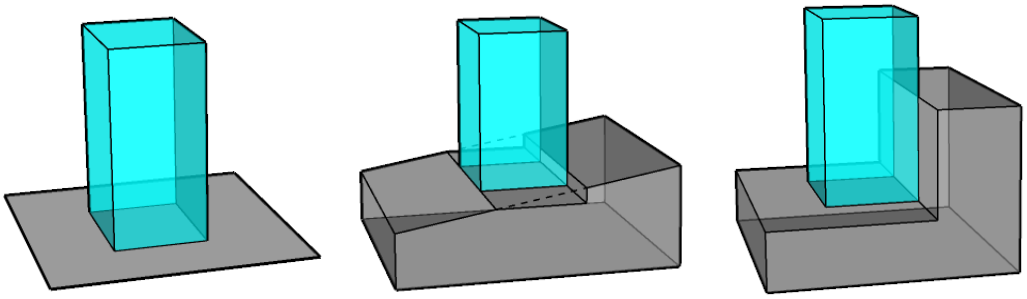
Figure 1. Different grounds in two sides

A **B**

Figure 2. Different ground levels for different buildings: A) top level to ground level; B) ground level to the top level and middle level.

In order to clarify the relation between the building and earth surface, we divive the earth surface into three types: plannar surface, slope surface and terraced surface (Figure 3). Also, we define two faces: bottom face refers to the lowest bottom face of the building and base face refers to the face where building entrances locate. The entrance, as a key part in building, connects the outside and the inside space which is generally choosed as our daily perception

place. Obviously, the based faces for one building may be more than one. As the main node connecting outside, base face / entrance is the important cognitive place that is formulated by “gound” marked with level 1 or level 0. For terraced surface, the building may have multiple base faces with different entrances that influence our cognition about building hight and direction concepts of front/back sides.



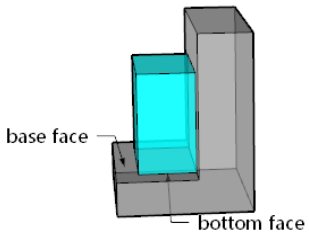
A plannar **B slop** **C terraced**

Figure 3. Different ground surfaces with the building sites

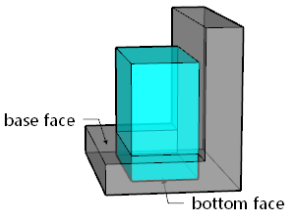
We take the complex terraced surface for example to analyse the category about relationships between the 3D building property and earth surface. Four types can be listed:

- There is only one base face that coincide with bottom face and the terraced top is higher than the building (Figure 4A)
- There is one base face and base face doesn’t coincide with bottom face, also the terraced top is higher than the building (Figure 4B)
- There is multiple base faces and one of base faces coincides with bottom face (Figure 4C). Comparing the elevation between another base face and bottom face, there could be three types as Figure 4C shows. Real case of HONGYADONG in Chongqing City in Figure 5 meets the type in Figure 3c with terraced ground, two main entrance locate at two base faces.
- The building has multiple base faces that is not coincide with bottom face, and this senario happens when bottom face locates underground (Figure 4D).

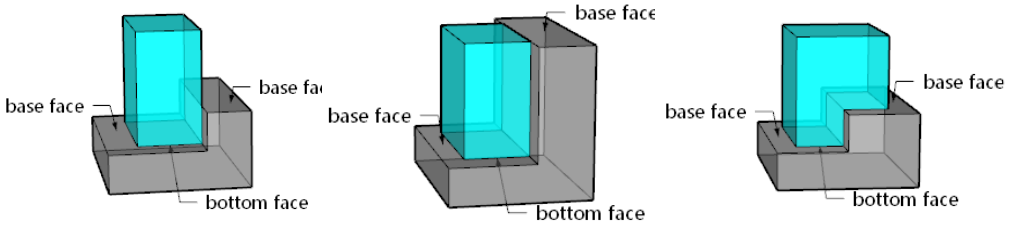
Clear description of the relation between building property and terraced ground can enhance the storey semantics about the building. For Figure 1B, there are two base faces with entrances, and A is marked with L1, then B is marked with LG (lower ground); different levels are sequently marked according to A and B.



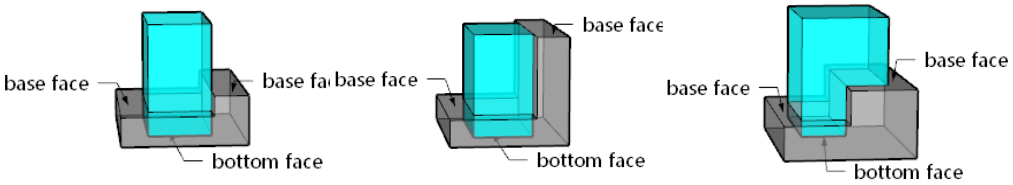
A One base face and one bottom face (coplannr)



B One base face and one bottom



C Multiple base faces and one of them coincide with bottom face



D Multiple base faces and different bottom face

Figure 4. The relationship between 3D building property and terraced terrain (grey color for the surface and red color for building property)

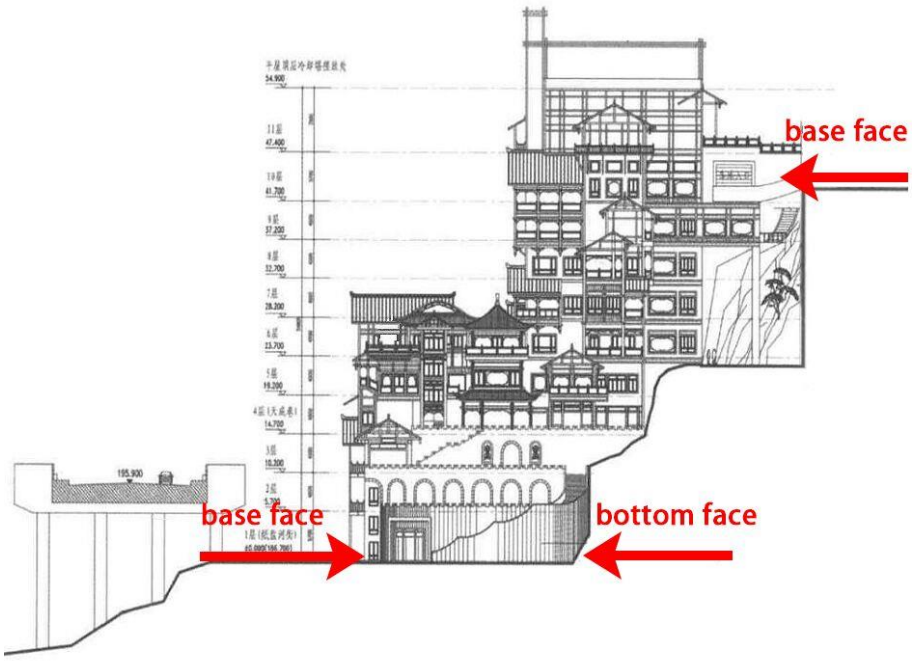


Figure 5. The diagram of relationship between Hongyadong and ground surface

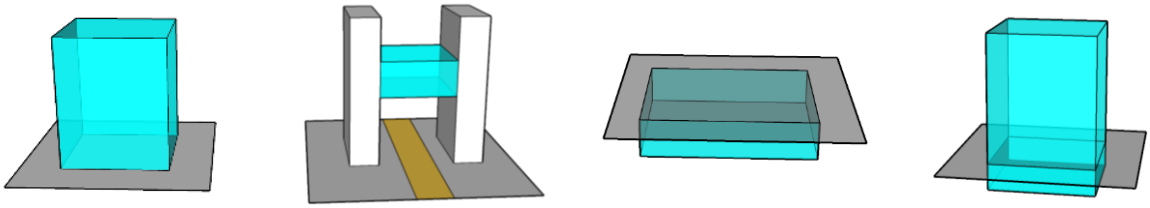
3. EARTH SURFACE REFERENCE

Even the ground levels are there, we still need to understand the air building and underground space, to get correct relative locations comparing to the ground surface. Moder construction techniques support the buildings and man-mad to the air and underground as Figure 6. In China the new Civil Code (2021) stipulated that the ownership/usership can be set up in the air and underground.

A Overstreet building **B Underground street** **C viadust through the building**

Figure 6. Buildings extending into overground and underground space

Spatial location and shape of 3D property in 3D cadastre should be clearly portrayed (Stoter, 2010), also this explicit descriptions should include spatial relationships relative to the earth surface. In full 3D cadastral system, 3D relative vertical locations can be described as Figure 7 in four types: on the surface, in the air, underground and across the surface.



A on surface **B in the air** **C underground** **D across the surface**

Figure 7. Relative locations between 3D building property and the ground surface (grey color for the surface and red color for building property)

4. CORRESPONDENCE BETWEEN 3D BUILDING PROPERTIES AND SURFACE PARCEL

For administrative management, the basic unit is the parcel, mostly 2D parcel. When the focus moves to 3D parcel, it locations and connection with 2D parcels become more complex. One 3D parcel may touch more than one ground 2D parcels, like the overroad building connects two buildings with ground parcels (Figure 6A). When we think the relations in 3D space, one 3D parcel is “inside” in another 3D parcel, for example, the metro goes through the building in 3D space (Figure 6C).

3D parcel in 3D Cadastre is an spatial occupy with RRRs (Ying Shen, et al., 2015), and its indeed registration can be independent of the surface parcel (Shi yunfei, 2009). Taking the general understanding abour surface reference in our daily cognition, it is necesary to describe the correspondence between 3D building property and 2D surface parcel to reflect the vertical overlap between them. We conclude the correspondence between 3D building property and 2D surface parcel in four types: one to one (1-1), one to multiple (1-m), multiple to one (m-1) and multiple to multiple (m-m) (Figure 8).

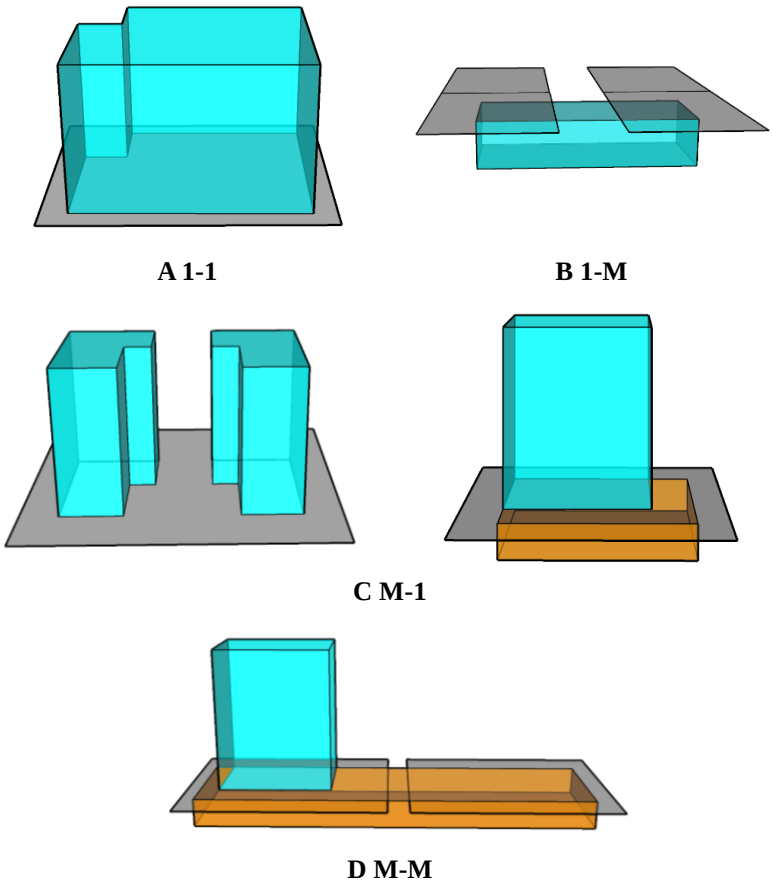


Figure 8. Correspondence between 3D building property and 2D surface parcel (grey color for the surface and red color for building property)

5. CONCLUSION

3D building property is the main object in 3D cadastre, and correct classification and analysis between 3D building property and earth surface would enhance the descriptions and the segmentation of 3D building property and promote the understanding about spatial situations and right analysis for 3D building property. The paper demostrates real cases and analyses the spatial relationships between building property and earth surface, and with these descriptions, further analysis about the consistency between legal geospace and physical geospace of building property, spatial relationships between 3D building properties can be detailed with legal system and RRR constraints.

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BIOGRAPHICAL NOTES

Shen YING is a professor in School of Resource and Environmental Sciences, Wuhan University. He received a B.S. (1999) in Cartography from Wuhan Technique University of Surveying and Mapping (WTUSM), and MSc and PhD degree in Cartography and GIS from Wuhan University in 2002 and 2005, respectively. His research interests are in 3D GIS and 3D cadastre, Geo-linked data, GeoVisualization. Also he is a guest researcher in Key Laboratory of Urban Land Resources Monitoring and Simulation, Ministry of Natural Resources.

Hanrui SUN is a master student in School of Resource and Environmental Sciences, Wuhan University.

Chengpeng LI is a PHD student in School of Resource and Environmental Sciences, Wuhan University.

Wenting ZHANG is a master student in School of Resource and Environmental Sciences, Wuhan University.

Meng WANG is a PHD student in School of Resource and Environmental Sciences, Wuhan University.

Yong ZHAN is an engineer in Chongqing Survey Institute.

Yu ZHANG is an engineer in Guangzhou Urban Planning Survey Design & Research Institute.

Xueye CHEN is the director of Key Laboratory of Urban Land Resources Monitoring and Simulation, Ministry of Natural Resources.

CONTACTS

Shen Ying
Wuhan University
School of Resource and Environmental Sciences
430079 Wuhan
PR CHINA
Tel.: +86 27 68778294
Fax: +86 27 68778893
E-mail: shy@whu.edu.cn
Website: http://faculty.whu.edu.cn/show.jsp?n=YING%20Shen