Reasons and countermeasures of traffic congestion under urban land redevelopment

Yanli Wang\textsuperscript{a}, Xiaoyu Zhu\textsuperscript{b}, Linbo Li\textsuperscript{a}, Bing Wu\textsuperscript{a*}

\textsuperscript{a}Key Laboratory of Road and Traffic Engineering of Ministry of Education, Tongji University, Shanghai, 201804, China
\textsuperscript{b}National Center for Smart Growth Research and Education, University of Maryland, College Park, MD 20742, USA

Abstract

Urban land redevelopment which is a reconstruction on a previously developed area with existing transportation facilities is an important component of city evolution. While improving land use efficiency, it can bring negative impact to transportation system, such as causing traffic congestion. Especially in China, there are many examples about redevelopment projects causing traffic congestion. For a better guidance of land redevelopment of China, it is necessary to find the reason caused traffic congestion after urban land redevelopment and provide some corresponding countermeasures. The objective of this study is not only to attract attention to the transportation during urban land redevelopment planning and management, but also to provide a way to reduce traffic congestion. In this paper, we first analyzed why traffic congestion happened after urban land redevelopment through some classical examples. We didn’t stop at the apparent reason, but do deep analysis. As a result, we uncovered the traffic congestion after redevelopment is due to inappropriate land use and transportation facilities under redevelopment, but the real cause is originated from urban and transportation planning and management. Consequently, we offered some corresponding countermeasures from three aspects: (1) before development, integrate urban land and transportation and do a rational planning to avoid inappropriate redevelopment planning; (2) during development, improve and strengthen management and control to ensure that the redevelopment project are proper; (3) after redevelopment, implement traffic congestion management of both traffic supply and demand to relief traffic congestion.

Keywords: Urban land redevelopment; traffic congestion; planning and management; integrated model; mechanism; traffic impact analysis

1. Introduction

Urban development is a constantly building and updated metabolic process, and urban land redevelopment (a reconstruction on a previously developed area) is a fundamental way of urban development. In western developed countries, redevelopment has become the main way of urban built environment evolution especially after World War II.
War, and they have carried out a lot of urban renewal movement such as the redevelopment of old residential or industrial zones (Carmon, 1999). While, in China, though it is still developing, there are also many blocks (e.g., original industrial land in downtown) need to be redeveloped (Leaf, 1995). Redevelopment is especially important for the metropolitans where the available building land is limited and the part of the pre-existing land use is not efficient to afford the increasing development in population and economy. It can not only reuse and improve land use efficiency, but also update the original land use (including land type, land structure, and so on) and make regional land layout optimization possible. Therefore, urban land redevelopment is extremely important for the future. That is why many cities in China including Shanghai, Beijing, and other cities are carrying out urban redevelopment projects.

However, urban land redevelopment will inevitably bring some impact on transportation system when changing the land use to improve efficiency. It might conducive to public transport and relief traffic congestion, or may cause traffic problem and even lead to or exacerbate traffic congestion. There are many positive examples, such as the transformation of the London Docklands, the redevelopment of the waterfront in Boston, and Vancouver’s Expo redevelopment. They all effectively coordinate the development of land reuse and transportation, thus, optimize regional land layout and alleviate local traffic congestion. While, in China, there are more cases cause or exacerbate traffic congestion due to redevelopment. For example, the large-scale redevelopment of Central Business District (CBD) in Beijing in 21st century once brought heavy traffic to this region due to the emergence of a large number of tall buildings, which made residents and employees “unable to enter or unable to go out” at peak time. The government improves the road network and facilities later, but traffic congestion still exists in rush hour since the implementation of public traffic system drop behind the fast and high intensity redevelopment. Another example in Beijing is the reconstruction of the old town Haidian into Zhongguancun, and it is also caused traffic congestion and become one of the most congested areas. There are also many cases which brought heavy traffic in other cities: the redevelopment of Kerry Sleepless Town (near railway station) in Shanghai, the reconstruction of CBD in Shenzhen, and so on. The negative examples actually failed to improve land use and living environment, and they are not conductive to the sustainable urban development.

Currently, there are a large number of researches on urban traffic congestion. Some researchers including Taylor (1992) try to find the nature of traffic congestion; some (Maitra et al., 1999) study on the models and simulations of traffic congestion; some analyze what caused traffic congestion (Holmes and Leonard, 1993; Huang et al., 2007); and also some researchers as Li (2004) summarize the regular pattern of traffic congestion; among them, Taylor (2002) point out the importance of land use factors to congestion, while many researches (Cervero, 1991; Dunphy and Fisher, 1996) are done on the relationship between traffic behavior under different land use and congestion. But there are few researches on the traffic congestion under redevelopment expect the study of congestion developing process (Wang et al., 2011). Since redevelopment is more important and brings a lot of traffic congestion, it is necessary to do deep analysis of the reasons and to give measures avoiding congestion. As we known, different countries have different policy and means, so the reason and countermeasures for congestion are also different. Here, we focus on the cases in China. In the next section, we try to reveal what caused traffic congestion in the whole process of redevelopment, and analyze the reasons from appearance to essence. After that, the corresponding measures are given to avoid and relief the congestion. At the end, we show the findings and conclusions, and also give our recommendation.

2. The reason analysis of traffic congestion after urban land redevelopment

2.1. The apparent causes
The apparent cause for most traffic congestion is the conflict between travel demand and supply. For the case of redevelopment, the changes in demand and supply under different planning scenarios bring or exacerbate the traffic congestion through the following two situations.

- **The redevelopment increase in only demand but not supply.** In this situation, the level of service declines with the increasing demand and the unchanged supply. When the demand exceeds the capacity of supply, then the congestion occurs. This is easy to see from figure 1 (a).

- **The redevelopment increase in both demand and supply.** In this situation, Transportation infrastructures are constructed to increase the capacity simultaneously with the increasing in travel demand under redevelopment. But if the increase in travel demand is larger than the improvement in the capacity, the congestion will occur. Figure 1 (b) shows why congest in this situation clearly.

![Fig. 1. Congestion happened situation after redevelopment](image)

Overall, the appearance causes for traffic congestion after redevelopment is that the transport supply capacity cannot afford the demand under redevelopment. The positive or negative impact depends on the comparison between the increases in demand and supply. The occurrence and exacerbation of traffic congestion after redevelopment is due to more traffic demand increased than the transportation improved under redevelopment.

### 2.2. The basic causes

The redevelopment project itself is the source of the outcome that the supply cannot afford the demand. The unsuitable land use and the insufficient in transportation infrastructure are the major reasons.

#### 2.2.1. Unsuitable land use

**2.2.1.1 Unsuitable land use type**

The land use type decides the function of the plot and the travel demand. Inappropriate function may increase the trip generation and attraction dramatically, or make the trips more concentrated in peak hours, or increase trip distance and duration, or bring more auto travel. As a result, large amounts of traffic flow appears at the surrounding roadway network, which will cause congestion in peak hours or longer waiting time under congestion.

The rationality of land use type should be defined jointly with the layout of surrounding land use and the function of the transport network. For example, an industrial plot surrounded by residential plots is not suggested to be redeveloped to residential plot, because it will increase trip distance and peak hour traffic. Figure 2 shows a redevelopment case for this example (a industrial plot was redeveloped into housing) in Shanghai. The result of
this redevelopment is the congestion of Changzhong Road and South Jiayang Road. Besides, the plots along the major arterial road which is defined as express way or fast road should not be redeveloped to generate huge traffic because the vehicles go in or out this plot will bring a lot disturb to the existing traffic. There are many cases can explain this principle. E.g. along the West of the Second Circle Road in Xi’an, there are many public service, education, entertainment, shopping and business facilities, which attract many traffic and roadside parking, and the segment turns to a bottleneck and cause congestion.

2.2.1.2 Unsuitable land use intensity

The intensity decides the amount of trip production and attraction. The common situation in China is the ultra-high intensity development, which means the density or volume exceeds the capacity of the overall transportation system.

Similarly, the rationality is identified corresponding to the surrounding regions, especially the network capacity. For example, the plot in the area with existing congestion problems should avoid the high intensity redevelopment, e.g., the over-limit redevelopment in Shanghai rail station cause the congestion even wore in West Tianmu Road especially in the intersection of Meiyuan Road and queuing over several intersections in peak hours (see Figure3).
Also, the area with insufficient public transit is not suggested for high-intensity redevelopment, such as the case in Beijing CBD area. The unmatched transit system cannot afford the travel demand after redevelopment and there are more travel using private car on the roadway network.

2.2.2. Inappropriate infrastructure supply

This inappropriate supply is caused by many situations according to the land use redevelopment, such as the unmatched interior affiliated facility with the demand, and delayed facility construction with the project plan.

The main issues of supply for the interior are discussed below. (1) The location and number of entrances and exits of the plot by different mode conflict with the connection segments. If the flow entering the internal road through the exit exceeds the residual capacity, the road with the exit will be congested. In addition, if the motorized and non-motorized traffic route has many conflicts with the existing traffic on the road, there are high potential of congestion by incidents. (2) Location and capacity of parking facility in the internal plot will also raise the problems of irregular parking and congestion. This is a frequent scenario in business plot redevelopment, such as the food street in Wuhu City where the insufficient parking lots initiate the congestion in peak hours with many irregular parked vehicles. (3) Interior design such as intersections, crosswalks, number of lane, dividends and non-motorized facilities is also a reason of traffic congestion.

For the external road, the demand after redevelopment will change the traffic flow on the adjacent road. Similarly as the issues for interior plot, the traffic at the exit can be affected by the design of the connections. Also the adjacent road should be better operated for the increased motorized and non-motorized traffic because the increased traffic may exceed the capacity of some section or intersection. For instance, the redevelopment at 4th-6th district in Changning Road initiated huge amount of traffic, especially the left turn and U-turn traffic flow at the Changning-Wanhangdu intersection (see figure 4). Adjustment for the left turn signal timing is required to release the queue of left turn. Also, the bottleneck for the new traffic, Changning road, needs better operation. Another example is the congestion on South Chang’an road in Xi’an, where has new business, entertainment and restaurant and larger school, but no improvement on the road facility.

![Fig. 4. The surrounding land use and roads of the redevelopment site at Changning Road](image-url)
In conclusion, the unreasonable land use and insufficient transport supply are the fundamental reason of conflicts in demand and supply and congestion.

2.3. The underlying reason

The underlying reason can be revealed further as the weakness in planning and management.

- The urban land planning and traffic planning are done separately, so it causes the incoordination between the land use and urban planning.
- The management is not strictly because there are no related legal, so the estate real estate developers construct the buildings beyond the intensity limit as that they can get more economic benefits. And also the traffic impact analysis system didn’t play the role effectively.
- There is no effective model which can completely integrate land use and transportation properly.

3. Countermeasures for traffic congestion due to redevelopment

3.1. Countermeasures of urban redevelopment planning

First, periodical travel survey should be conducted by the urban planning and transportation planning agencies. The survey can reveal the travel patterns, land use characteristics, and will be used to estimate the parameters in the transportation model. Then, construct integrated framework for land use and transportation planning according to the specialty of the study area. Also, assessment scheme, such as the traffic impact analysis (TIA) for the planning proposal is request to verify the feasibility and rationality of the project. Finally, it is necessary to coordinate the urban plan and transportation plan closely with frequent interactions and feedbacks scheme.

3.2. Countermeasures during the process of urban redevelopment

Redevelopment process should be managed and supervised in proposal, assessment and execute. Here we propose the countermeasures from three aspects: the developing approach, the TIA system, and the management of the process.

3.2.1. Improve the developing approach

The redevelopment project different from general development project should not simply transfer the whole land property rights through market-based instruments to real estate developers. And the “land completely flat” is also not suit for redevelopment. The existing developing approach or path need to update trough including the context as flow to ensure the developing approach consist with planning:

- Increase public participation, and make sure it is planning-oriented under the joint control of the city planning department and land management agency.
- Combine of government intervention and market mechanisms flexibly with a variety of development pattern such as the redevelopment can be done partial rather than the whole plot.
- Diversify the implementers and the path of redevelopment projects, Government or the residents can be the main developers. Government, developer, and public should be involved together for reasonable redevelopment plan.

3.2.2. Improve the traffic impact analysis system

Improve the traffic impact assessment system from both horizontal and vertical. Horizontal improvement include: (1) add some evaluate measures or context for public traffic and non-motorized traffic (Wang, 2013); (2)
increase special instructions and supplemental content for redevelopment traffic impact analysis; (3) strengthen the relevance and implementation of the improvement measures such as the specific internal and external improvement measures or operational traffic organization. Figure 5 provides the process of traffic impact analysis, and shows the steps which need to improve or note.

![Fig. 5. The process of the traffic impact analysis](image)

Horizontal improvement means increasing the universality of TIA and putting TIA into effect in multiple stages including planning stage, the site selection stage and the construction stage.

3.2.3. Strengthen the regulatory of the redevelopment process

Regulatory by government agencies are important to assure the completeness of the affiliated facilities and the rationality of the project. Every step in the process including TIA for the planning scenarios should under control strictly to ensure it consistent with the planning. Once some error is found, the effective management should implement immediately.

3.3. Countermeasures after the urban redevelopment

For the existing and the inevitable congestion caused by the redevelopment, the problem should be further mitigate by managing and controlling both transport supply and traffic demand, similar as the general traffic
congestion management and improvement strategies. Here, several targeted measures are given as follow for congestion after the redevelopment.

Improve the operations and management level should be the preferred method. (1) If the redevelopment cause some intersection congested, adjust the traffic signal control first, such as adding a non-motor vehicle phase or adjusting the pedestrian green length and cycle length, and then redesign the intersection such as providing left-turn bay for vehicles or broadening the crosswalks. (2) If some sections are congested after redevelopment, judge if it can apply the lane change management to ease crowding, if adding (or changing) the crossing facilities or installing the central fences to avoid jaywalking is effective, otherwise widening the section or non-motorized vehicles lanes or sidewalk. (3) If the congestion happen around the entrance of the redeveloped site, try the “right in, right out” entrance manage, and add or cut back the crossing facilities to make the traffic orderly which can increase efficiency and smooth.

4. Conclusions

From the above discussion, the traffic congestion due to redevelopment is caused directly by the incoordination of transport demand and supply after redevelopment the network capacity after redevelopment cannot afford the traffic demand. So the redevelopment project itself including the unsuitable land use and the insufficient in transportation infrastructure is the source of the congestion. Therefore, the congestion issue depends on the land use and transportation system jointly, and can be avoid with appropriate planning and evaluation scheme and effective supervision.

Corresponding countermeasures are suggested from three aspects: (1) before development, integrate urban land and transportation and do a rational planning to avoid inappropriate redevelopment planning; (2) during development, improve and strengthen management and control to ensure that the redevelopment project are proper; (3) after redevelopment, implement traffic congestion management of both traffic supply and demand to relief traffic congestion.

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References


