Citation: ZHOU Sien, Kou Chunge, Ru Xianghui, Zheng Meng. Techniques of Planning Control along Arterial Railways: A Case Study in Beijing [J], Urban Transport of China, 2018 (02): 43–50.

Techniques of Planning Control along Arterial Railways: A Case Study in Beijing

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Abstract: In order to promote the coordinated development of arterial railways and land use along railways, this paper analyzes the implementation and challenges of planning along arterial railways in Beijing and proposes the principles and method of planning control. Based on related standards and specifications in the world, the paper identifies the factors influencing planning control along arterial railways, such as safety, noise, vibration, greening, and nuclear magnetic radiation, as well as corresponding indicators. Aiming at both the development needs of railway and cities, the paper proposes the planning control techniques of "Two Areas and Three Lines", that is, isolation belts and planning control areas along arterial railways, the starting line, the protection line, and the planning control line. The functional layout along arterial railways, city zoning, control indicators, and technical requirements of planning control are also elaborated. Finally, the paper discusses the sensitivity of land use under the influence of the planning control method, and proposes corresponding countermeasures. **DOI:** 10.13813/j.cn11-5141/u.2018.0205-en

Keywords: transportation planning; arterial railways; planning control; isolation belt; planning control area; planning implementation

An urban yellow line is the control line of land use for infrastructure during the city planning stage, which has a significance influence on the holistic development of cities. Despite the importance of Arterial Railways (ARs) in the city development, there is scarcely any clear regulation about the AR Planning Control (PC). Some national standards and specifications referred to Arterial Railway Planning Control (ARPL), for example, the national standard of *Code for Intercity Transportation Planning GB50925—2013* proposed the PC line for each railway classification outside the urban built-up areas; the *Specification of Urban Greening Planning and Construction Indicators* released in 1994 by former Ministry of Construction makes certain that the shelterbelt width on each side of the railway should not be less than 30 meters. Moreover, several PC specifications for ARs like isolation belts or green belts appeared in government orders, city master plans, or planning technical requirements in some cities like Beijing and Guangzhou. Besides, many researchers also conducted some studies about ARPC from viewpoints of noise control [1–2], operational safety and PC [3], landscape integration along ARs [4] as so on.

The above mentioned literatures have positive effects on ARPC, but still some challenges about ARPC exist in the new period as follows: 1) both the indicators and requirements for ARPC are unclear. Although many current AR standards and specifications focus on operational safety, isolation belt, green belt and so forth, it is hard to synthesize all these indicators and requirements, and it has a weak coordination effect during the process of planning implementation. 2) The conventional planning regulations are facing challenges from the technological innovations of high-speed railways, and the ARPC requirements are in urgent need to be accordingly updated. 3) With the improvement of urban life quality, the land use along ARs is necessary to be implemented with PC for the countermeasures settlement including decreasing noise, vibration, and radiation, as well as integration of landscape, greening and buildings along ARs. Moreover, there are great differences and possible conflicts of ARs with city and country construction in the aspects of administrative system, institutional framework, planning and planning implementation, construction sequence and time cycle, so it is imperative to carry out studies about ARPC requirements.

1 Current situations of PC along ARs

1.1 Current PC situation

The majority of standards and specifications about land use control along ARs are formulated from viewpoints of safety protection, noise control, or environmental greening, among which corresponding definitions of PC are different like isolation belt, protection zone, buffer zone, greening

Received: 2017-02-04
Supported by: Beijing Municipal Science and Technology Project (PXM2016_084202_000020)
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zone, and so on. In Beijing, the primary specification about ARPC is *Temporary Provision about Planning, Construction and Administration of Isolation Belt along Beijing Arterial Railways* issued in 1989, which is also called NO. Seven Government Order (NSGO). The NSGO takes ten ARs like Jingshan railway as PC subjects, and the width of isolation belt is 30 meters from each side of outer track of ARs when ARs go through the town or city areas, and accordingly 100 meters for the plain agricultural areas. Any new or expanded urban construction works are not permitted in the above 30-meter or 100-meter isolation belt areas.

1.2 Challenges of new situations on the current PC specifications

The NSGO has played a positive role in regulating land use along ARs during Beijing urbanization, but some challenges exist as follows:

1) The establishment of a multi-level and multi-mode railway system broken through the PC scope and requirements of 10 AR subjects in the NSGO.

According to the 2016 edition of *Beijing Railway Terminal Master Plan—Overall Urban Planning of Beijing (2016–2035)*, Beijing would establish a multi-level and multi-mode railway system composed of high-speed railways, common speed railways, regional express railways and so forth. Besides the 10 AR subjects in the NSGO, there appear some ARs like inter-city dedicated passenger railways, inter-city high speed railways, regional express railways in Beijing metropolitan area and Beijing–Heibei–Tianjin integration area, and the length of newly built or renewed ARs would extend over 1 000 kilometers. Therefore, the current PC scope and requirements cannot meet the needs of future AR plan.

2) The rapid development of high-speed ARs requires updated supporting technical standards and indicators.

The fast development of high-speed railways, with characteristics of high speed and large turning radius, breaks through some of the current technical requirements. The design of railway lines and the settlement of countermeasures like promoting safety, decreasing noise and vibration lead to more need of land use and protection zones.

3) To accommodate the higher standard of noise control, more powerful countermeasures are necessary for urban environmental protection.

In order to satisfy the increasing demands of city environmental quality, urban environmental protection agencies have raised the standards of urban noise control. However, many studies show that the practical noise levels along ARs do not accord with the standard levels [5]. It is necessary to reserve enough space for enhanced countermeasure settlement and noise level controlling.

4) To solve the problem of "Not in My Backyard" in railway construction, the ARPC specifications are in urgent need to be improved.

The "Not in My Backyard" phenomenon is a primary source of social risks for railway construction in the urban centralized construction areas. Take Beijing–Shenyang high-speed railway as an example, its outer track is 58 meters away from the residential area, but still the residents oppose the construction of the high-speed railway. Therefore, it is imperative to develop ARPC regulations, providing legal basis on solving the problem of "Not in My Back Yard".

5) The AR planning implementation encountered difficulties and obstacles such as the inharmonious relationship between the NSGO and the city master plan, and the ARPC problems emerged before the release of NSGO.

Despite the NSGO being a compulsory execution specification, it is not suitable for the majorities of AR corridors built prior to the release of NSGO. Meanwhile, the former Ministry of Railways plays a predominant role in AR plans, leaving less discourse power for the local government. Also, relevant ARPC specifications in the NSGO are not included in homochromous or later city master plan. The above-mentioned facts lead to inharmonious relationship between the NSGO and the city master plan. According to the NSGO criteria, the construction land use is not allowed in the isolation belt area, but there is nearly 1 000 hm^2 construction land use in the isolation belt areas along ARs, of which about 600 hm^2 are sensitive land use for residential purpose [6].

Due to the above-mentioned challenges, it is urgent to formulate ARPC regulations for the harmonious development of the AR and the whole city.

2 PC principles and conceptions

Not only the influencing factors like land use plan, noise, vibration, radiation, landscape, greening, and others, but also the need of railway and city development are considered to propose principles about the delineation and control methods of PC area.

2.1 PC principles

The principles about the delineation and control methods of PC area along ARs should be considered as follows:

1) It should accord with current specifications, standards, and engineering technical requirements.

2) The relationship between railway lines and adjacent land use should be analyzed, and the construction intensity and intensive utilization between inside and outside of cities and towns should be differentiated. Therefore, zone control along ARs is recommended.

3) According to the principles of systematicity, integrity, and comprehensiveness, the influencing factors like operational safety, greening, noise, vibration, radiation and other factors are considered to make certain spatial function adjacent AR lines. Corresponding PC indicators and technical requirements are formulated by differentiating the primary

or secondary importance of the former mentioned influencing factors. Current standards and specifications about PC along ARs are also considered.

4) For different land use types along ARs, the sensitivity to noise, vibration, radiation, and other factors are analyzed to refine the study of PC indicators and requirements.

5) The principles of economical land use, the foresightedness, maneuverability and sustainability of PC should be considered.

6) The factors including railway functional classifications, future possible speed-up of ARs, and compound railway corridors should also be considered. Compared with the differences of functional classifications between inter-city railways and high-speed railways, the factors about future possible speed-up of ARs, compound railway corridors and "Not in My Back Yard" phenomenon are more important. Therefore, the PC indicators of inter-city railways and high-speed railways should be set at the same high level.

2.2 PC conceptions

The PC conceptions along ARs are shown as Figure 1.

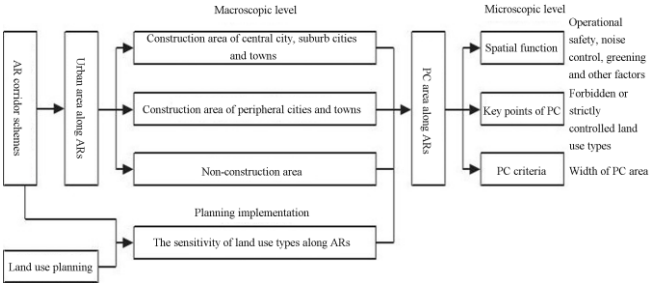

Figure 1 Framework of planning control along arterial railways

1) The dual demands of human being and railway development should be considered under the new technology situation.

2) Different PC requirements in accordance with land use types along ARs should be analyzed.

3) The macroscopic and microscopic level PC requirements should be integrated together. At the macroscopic level, the different PC indicators are implemented according to the city zoning along ARs. For example, the PC indicators along ARs in the central city, suburb new towns, peripheral new towns, construction area or non-construction area are different. At the microscopic level, a certain level space outside the AR track line is defined as PC zone. The spatial function, key points and indicators of PC are developed by considering the requirements of operational safety, greening, noise control and other factors, also in accordance with current standards and specifications about ARPC.

4) Both the planning and implementation should be integrated. According to the NSGO criteria, the construction land use is not permitted in the isolation belt area, but there are lots of construction land uses in the isolation belt areas along ARs, and among them there are even sensitive land use like residential land use. The area amounts of the construction land use show a kind of exponential growth curve with the width increase in the PC zone at different scenarios [6]. Therefore, when delineating the PC zones, great attention should be paid to the feasibility and maneuverability of the planning implementation, and meanwhile the PC and planning implementation should be integrated.

3 PC elements

Based on literature review, the influencing factors about PC along ARs should include operational safety, noise, vibration, greening, nuclear magnetic radiation and other factors. The establishment of all these factors' influencing scope should take relevant standards and specifications as primary references, and recent research findings should also be referred. The relevant standards and specifications can be subdivided into seven categories as planning management, operational safety, noise prevention control, vibration, greening, related professional disciplines and related overseas regulations.

1) The planning management norms mainly delineate a certain spatial area along ARs as PC zone by considering the factors like operational safety, noise, environmental protection and other factors. For example, some literatures, such as the norm of *Code for Intercity Transportation Planning (GB50925–2013)*, planning technical requirements of Chongqing, Zhengzhou and other cities in China, take the zone ranging from 15 meters to 60 meters in between ARs and adjacent buildings or structures as PC zone.

2) The operational safety norms mainly define a certain level of space along ARs as protection zone for the promotion of operational safety levels. The current national standard of *Railway Safety Management Regulations* proposes a 10 meters to 20 meters zone and 8 meters to 15 meters zone for high-speed railways and other railways respectively, which is calculated at each side along ARs from the railway structure line.

3) The noise prevention control norms define standard noise levels at a certain distance from the ARs, such as the national standards of *Environmental Quality Standard for Noise (GB3096–2008)* and *Technical Specifications for Regionalizing Environmental Noise Function (GB/T 15190–2014)*, most of which are in the charge of the urban environmental protection sector. Attention should be paid that the noise measuring distance is a virtual distance just for noise measurement, not the practical PC area.

4) The vibration norms are mainly to translate vibrations into equivalent noise levels, and then the vibration levels are proposed at a certain space level along ARs. Generally, the influencing levels of vibration are weaker than the counterpart of noise levels. Besides, there is rare regulation on nuclear magnetic radiation, and current research shows that under strict protection countermeasures, the levels of

nuclear magnetic radiation are controllable.

5) The greening norms mainly propose a recommended width of shelterbelt along ARs at different regions, usually 20 meters to 100 meters. For example, the national specifications of *Urban Greening Planning and Construction Indicators*, released by the former Ministry of Construction in 1994, proposed that the width of shelterbelt along ARs should not be less than 30 meters.

6) Related professional disciplines in Beijing, such as urban arterial roads, urban rivers, and urban shelterbelts, have designated protective zones with large zone width. In most cases, they are larger than 50 meters and generally 100 meters. For example, *Beijing City Master Plan (2004–2020)* has proposed that the green belt and the shelterbelt of "Five Rivers and Ten Roads" are in between 100 meters and 200 meters.

7) Related overseas regulations focus on railway boundary limit like height limit and width limit in the area of railway land use, usually inside the railway fence. Some areas have made regulations on prohibited structure types along ARs or arterial roads. For instance, in Soviet Union, the 100 meters sanitary protection belts on each side along ARs are required to be established. The width of the green belt should not be less than 50% of the width of the protection area. Roads, transportation facilities and structures are permitted within protection belts [7]. In terms of noise control, the noise standards are similar to the counterpart of China, but the practical noise levels at measured places are mostly satisfying local criteria.

The PC elements and indicators from the above mentioned literatures are shown as Table 1.

4 PC technical requirements

4.1 Divisions of spatial functions along ARs

Based on the standards and specifications such as *Railway Safety Management Regulations*, *Technical Specifications for Regionalizing Environmental Noise Function (GB/T 15190–2014) and Environmental Quality Standard for Noise (GB3096–2008)*, the "two areas and three lines" ARPC conceptions are proposed (Figure 2). The two areas are isolation belt area and PC area, and the three lines are starting line, protection line and PC line.

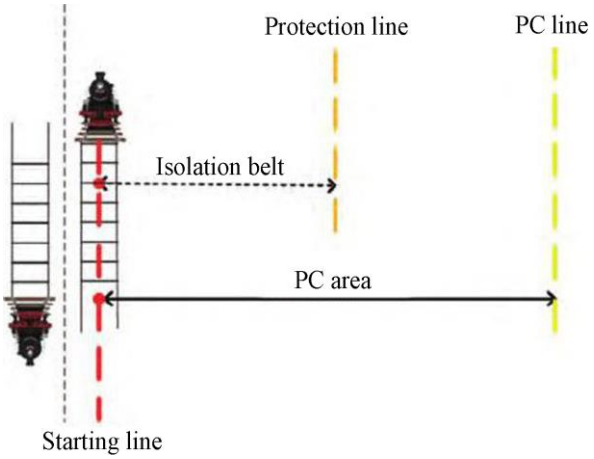

Figure 2 "Two Areas and Three Lines" of PC along ARs

1) Isolation belt

The primary function of isolation belt is to ensure the structural stability and operational safety of ARs, to prevent external factors from interfering with train operation, and to eliminate possible transportation safety hazards. It is a specific area set up to limit the actions affecting AR transportation safety, and its main functions include guaranteeing safety, greening as well as noise reduction.

2) PC area

Besides the isolation belt area, PC area extends the lateral boundary line of isolation belt area to a certain distance away. As for the isolation belt area, the primary function is to safeguard operational safety and greening, and the auxiliary function is to decrease noise to a certain level. As for

Table 1 PC elements and indicators according to related standards and specifications

PC element	Indicator	Source
Railway operational safety	The width range of safety protection zone is a 10 meters to 20 meters zone and an 8 meters to 15 meters zone for high-speed railways and other railways respectively, which is calculated at each side along ARs from the railway structure line.	*Railway Safety Management Regulations*
Urban noise control	The standard noise levels for three levels of sound environmental function area are as follows: the 1st level, 50 meter ± 5 meter, daytime, 55 db, nighttime, 45 db; the 2nd level, 35 meter ± 5 meter, daytime, 60 db, nighttime, 50 db; the 3rd level, 20 meter ± 5 meter, daytime, 65 db, nighttime, 55 db.	*Environmental Quality Standard for Noise (GB3096-2008), Technical Specifications for Regionalizing Environmental Noise Function (GB/T 15190—2014)*
Related research	The 1st level area include residential areas, cultural and educational areas, residents concentrated areas and centralized areas of government and institutions, and the width of PC area is 140 meters. The 2nd level area include mixed land use type area of residential, commercial and industrial, planned business district, and the width of PC area is 100 meters.	*Study on the Width of the Railway Noise Transition Zone on Each Side of ARs (Source: the Institute Environmental Control and Labor Health, Ministry of Railways, China.)*
Urban greening and ecology	City construction area with the width of PC area ranging from 30 meters to 50 meters; peripheral city area with the width of PC area ranging from 50 meters to 100 meters.	Related standards, technical specifications and city planning reports from Shanghai, Guangzhou, Zhengzhou and other cities.
Related professional disciplines in Beijing, such as urban arterial roads and urban rivers	The 4th ring road with the width of PC area ranging from 50 meters to 100 meters; The 5th ring road with the width of PC area of 100 meters. The "Five Rivers and Ten Roads" with the width of PC area of 200 meters	*Specifications on Delineation of Isolation Zones on Both Sides of Urban Arterial Roads for Beijing, Beijing City Master Plan (2004-2020 years), Beijing Green Space Plan, etc.*

the area outside the isolation belt area but inside the PC area, the primary function is to reserve space for countermeasure settlement, such as the countermeasures like decreasing noise, vibration and radiation levels, also to reserve space for the future newly planned ARs. Besides, the intercity AR corridors in Beijing are relatively stable, and the possibility of widely opening up new corridors in the built-up areas in the city center or towns is much less than renewing and updating the existing AR corridors. Therefore, the PC area reserves a certain space for the newly planned ARs. Attentions should be paid that the PC area is for PC accompanying adjacent land use planning. It is not a necessary and sufficient condition for noise control to a certain criterion level. The noise levels should be complied with the criteria from the environmental protection sectors.

3) Three lines

The PC starting lines of ARPC are different according to different PC norms, such as railway structural line, railway land use boundary line, and outer railway track centerline (See Figure 3). The railway structural line is the horizontal projection line of the railway structure boundary, which is an irregular curve, having great difference in different railway sections like embankment, cutting, bridge, and other sections. The railway land use boundary line, also called railway land use expropriation line, is the boundary line of railway land use, mainly used for the right approval of railway land use by the government. From viewpoints of maneuverability, the outer railway track centerline is selected as the starting line. The protection line is the boundary line on the lateral isolating belt. The PC line is the boundary line outside the PC area. Considering the similarity of the PC line to the urban infrastructure land use control boundary in the *Urban Yellow Line Management*, the PC line can be taken as a kind of yellow line timely.

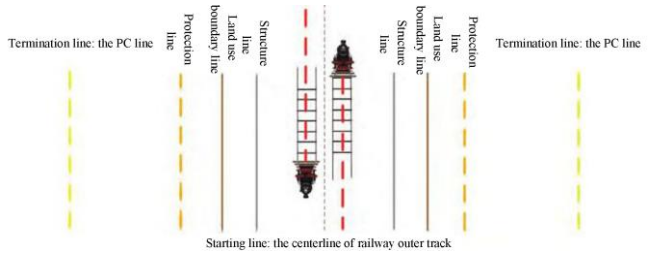

Figure 3 Reference line of planning control boundary

4.2 City zoning and PC indicators along ARs

1) City zoning

In line with the relationship between ARs and urban land use along ARs, the land use in Beijing can be divided into two categories, namely construction area and non-construction area (see Table 2). Under the situation of the functional dissolution of not being as a capital city function, the suburban new town is the important spatial area for function transfer, being a more and more important city functional area. Therefore, the PC indicator of the suburban new town should be similar to the counterpart of Beijing central city. The development objectives of peripheral towns are more ecological, livable, and suitable for industries, and the negative effects on the city production and life of residents along ARs should be reduced considerably. Meanwhile, the railway speed limit in the peripheral cities is much lower than that of the central city. More stringent PC countermeasures should be taken from the perspective of railway operational safety. Therefore, PC area along ARs can be divided into construction area and non-construction area overlapping with the central city, suburb new town and the peripheral new town, forming the basis of city zoning for the land use PC along ARs.

Table 2 City zoning

City area	City zoning	Scope
Urban construction area	Construction area of central city and suburb cities	Central city, Tongzhou, Shunyi, Changping, Daxing and Mentougou
	Construction area of peripheral cities and towns	Fangshan, Yanqing, Huairou, Miyun and Pinggu
Non-construction area	Urban area, plain area and mountain area	Greening isolation area, plain area, shallow mountain area, mountain area

2) PC indicators of isolation belt

The isolation belt begins from the starting line to the protection line. Within the isolation belt area, the range between the railway structure line and the protective line is the operational area based on the *Railway Safety Management Regulations*. The area width ranges from 10 meters to 20 meters and 8 meters to 15 meters outside the railway structure line for the high-speed railway and general speed railway respectively, when the railway passes through the city area, the suburban residential area, the residential area of the village and the town, and other areas. In order to ensure the planning elasticity, the high level PC criteria are adopted. When ARs pass through the built-up area, the 15 meters PC area for the high-speed railways is adopted. Also, the 20 meters PC area is adopted for the non-construction area.

The distance calculation between the centerline of the outer railway track and the structure line is based on the *Code for Design of High Speed Railway (TB 10621—2014)*, in which the standard sections of the subgrade and bridge are proposed (see Figure 4 and Figure 5). As for the subgrade section, the calculated distance is related to the height of the subgrade, and the general value is about 8.5 to 16.5 meters. As for the bridge section, the general value is about 3 meters. To ensure the foresight and long-term implementation of AR plan, the high level of 16.5 meters calculated distance for the subgrade section is adopted.

Therefore, under the general situation, the upper limit of the width of the isolation belt is 15.0 + 16.5 = 31.5 meters when the AR passes through the construction land use area, and 30 meters range is adopted as PC area. The upper limit of the width of the isolation zone is 20.0 + 16.5 = 36.5 m in the non-construction area, and 35 meters range is adopted as PC area.

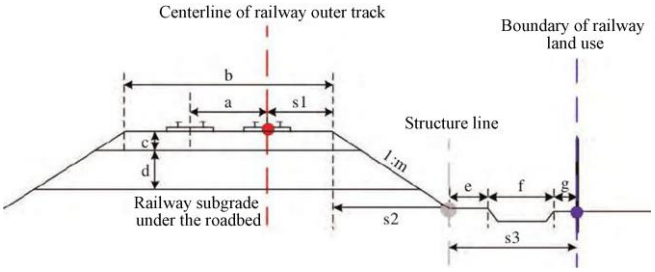

Figure 4 Cross section of roadbed

Source: it is drawn according to Reference [8].

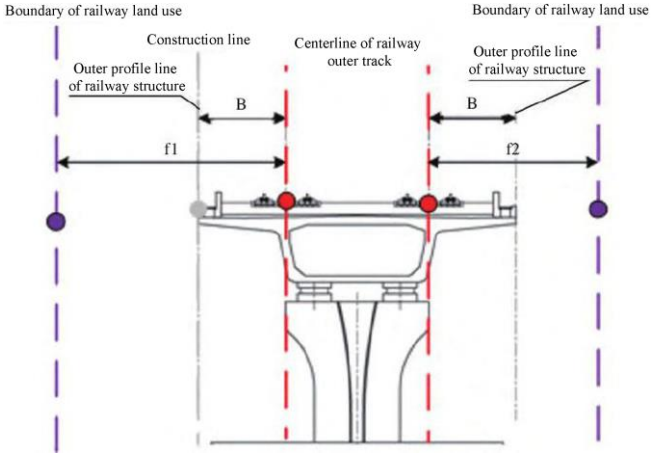

Figure 5 Cross section of bridge

Source: it is drawn according to Reference [8].

3) Control indicators for PC along ARs

According to current research, among the influencing factors of noise, vibration, and radiation for the delineation of PC area, noise is more sensitive to spatial distance than the factors of vibration and radiation. Therefore, noise is selected as the core determinant to the initial delineation of PC criteria. Then, the PC criteria are delineated prospectively by considering the influencing factors like "Not in My Back Yard" phenomenon, future possible speed-up of ARs, and expansion capacities of existing ARs in the future.

The PC area includes two components. The area between the railway land use boundary line and the PC line is delimited by referring to the standard of *Technical Specifications for Regionalizing Environmental Noise Function (GB/T 15190–2014)*, which defines five types of sound environments (see Table 3) and corresponding noise measurement distance levels. When the land use belongs to the 1st, 2nd, and 3rd types of sound environment, the noise measurement distance levels are 50 meters ± 5 meters, 35 meters ± 5 meters and 20 meters ± 5 meters, respectively. The five types of sound environments are applied to land uses along ARs. The belt length between the railway land use boundary line and the PC line is 50 meters ± 5 meters referring to the 1st type of sound environment, when ARs pass through the construction land use types in the central city and suburb new towns. Accordingly, 35 meters ± 5 meters referring to the 2nd type of sound environment, when ARs pass through the construction land use types in the peripheral cities and towns.

Table 3 Land use for functional areas in different sound environments

Sound environment		Land use type
Zero level		Rehabilitation area
The 1st level		Residential housing, medical and health, culture and education, scientific research design, administrative office
The 2nd level		Business finance, market trade, mixed use of residential, commercial and industrial land
The 3rd level		Industrial production and warehousing logistics as the primary functions
The 4th level	Level 4a	Expressways, Class I highways, Class II highways, urban expressways, urban arterial roads, urban sub-arterial roads, ground sections of urban rail transit and inland waterway channels
	Level 4b	Both lateral sides along ARs

Source: Reference [9].

The other area between the outer railway track centerline and the railway land use boundary line is delimited by referring to the standard of *Design Code for High Speed Railway (TB 10621—2014)*. The width of this area is generally in the range of 11.5 meters to 21.5 meters when ARs are located at the subgrade section (see Figure 4), and width for two lateral sides of ARs are f1 = 7.2 meters and f2 = 5.8 meters respectively when ARs are located at the bridge section (see Figure 5).

In conclusion, the PC indicators are established by integrating the influencing factors of urban zoning, land use economizing, countermeasures settlement of decreasing noise and vibration, landscape, as well as the foresight and maneuverability of future AR planning (see Table 4).

Table 4 Indicators for PC area

City area	City zoning	The area width between the centerline of outer railway track and the boundary line of railway land use	The area width between the boundary line of railway land use and the PC line	Total area width
Urban construction area	Construction area of central city and suburb cities	From viewpoints of economical land use, the lower limit values of bridge design standard ranging from 5.8 meters to 7.2 meters are adopted.	The area widths of 50 meters ±5 meters are used by referring to the measuring distance of the 1st level function area of sound environments.	In the 60 meters PC area, any of the sensitive land use type is not allowed, and the types of insensitive land use are strictly controlled. The municipal, roadway and other transportation infrastructures have immunity priorities if necessary after engineering studies.
	Construction area of peripheral cities and towns	From viewpoints of elastic development, the upper limit values of subgrade design standard ranging from 11.5 meters to 21.5 meters are adopted.	The area widths of 35 meters ± 5 meters are used by referring to the measuring distance of the 2nd level function area of sound environments.	In the 60 meters PC area, any of the zero, the 1st and the 2nd levels of land use types in Table 3 is not allowed.
Non-construction area	Urban area, plain area and mountain area	In the 100 meters PC area, any of the zero, the 1st and the 2nd levels of land use types in Table 3 is not allowed by referring to the document of NSGO.		

4.3 Hierarchical PC technical requirements for ARs

The three-level PC technical requirements for ARs are proposed based on the spatial function division of "Two Areas and Three Lines", city zoning, PC indicators and other factors (see Table 5).

Table 5 Hierarchical planning control

City area	City zoning	Isolation belt		PC area	
		30 m	35 m	60 m	100 m
Urban construction area	Construction area of central city and suburb cities	A		B	
	Construction area of peripheral cities and towns	A		C	
Non-construction area	Urban area, plain area and mountain area		A		C

1) Technical requirements for isolation belt

The rank A level of PC method is implemented for the isolation belt to safeguard operational safety. The widths of the PC area are 30 meters and 35 meters on each lateral side of ARs with the beginning line from the centerline of outer railway rack, when ARs pass through the construction and non-construction areas, respectively. Attentions should be paid that any new or expanded urban construction project is not permitted. When buildings and constructions within the isolation belt area bring possible operational safety problems, necessary countermeasures should be adopted. The buildings and constructions should be demolished according to relevant laws or regulations, when the operational safety levels cannot be met based on the adopted countermeasures. Besides, there could be some greening plants inside the isolation belt area if they do not block the view of railway drivers, also cultivated land can still be used for planting crops.

2) Technical requirements for PC area

The rank B and rank C levels of PC methods are implemented for PC areas, when ARs pass through the construction and non-construction areas, respectively. The widths of the PC areas for the two levels of B and C are accordingly 60 meters and 100 meters with the beginning line from the centerline of outer railway rack. Besides, there could be some greening plants inside the PC area if they do not block the view of railway drivers, also cultivated land can still be used for planting crops.

When ARs pass through the construction areas of central city and suburb new towns, the B-level PC is implemented. At this level, any sensitive land use type inside the PC area is not permitted. The sensitive land use types include all the land use types corresponding to the zero and the 1st type of sound environments, also all the land use types except the residential land use type corresponding to the 2nd type of sound environments. Moreover, the other land use types inside the PC area along ARs should also be strictly controlled. Besides, the municipal, roadway and other transportation infrastructures have immunity priorities if engineering studies show they are necessary. When ARs pass through both the construction and non-construction areas of peripheral cities and new towns, the C-level PC is implemented. At this level, all the land use types according to the zero, the 1st and the 2nd types of sound environments are forbidden. But the municipal, roadway and other transportation infrastructures have immunity priorities if engineering studies show they are necessary.

3) Applicability of proposed PC methods according to construction features

For the isolation belt, the proposed PC methods should be strictly implemented when ARs pass through the newly built urban areas. When the buildings or constructions in the isolation belt block the railway driver's view, countermeasures should be adopted according to the national standard of *Regulations on the Management of Railway Safety*. For the PC area, the proposed PC methods should be strictly implemented when ARs pass through the newly built urban areas. When ARs pass through the built-up urban areas, the current land use inside the PC area should be supervised until the urban constructions along ARs occur, and then the proposed "Two areas and Three Lines" PC methods should be strictly implemented.

4.4 Sensitivity and implementation suggestions of PC methods

All the ARs in the recent *Beijing Railway Terminal Master Plan (2016–2035)* are used as cases for the sensitivity analysis (see Figure 6). All the land use types corresponding to the zero and the 1st sound environments, also the land use types corresponding to the 2nd type sound environments except the residential land use type, are considered as sensitive land use types. The area amounts of PC area increase exponentially accompanying the increase in the width of PC area at different scenarios.

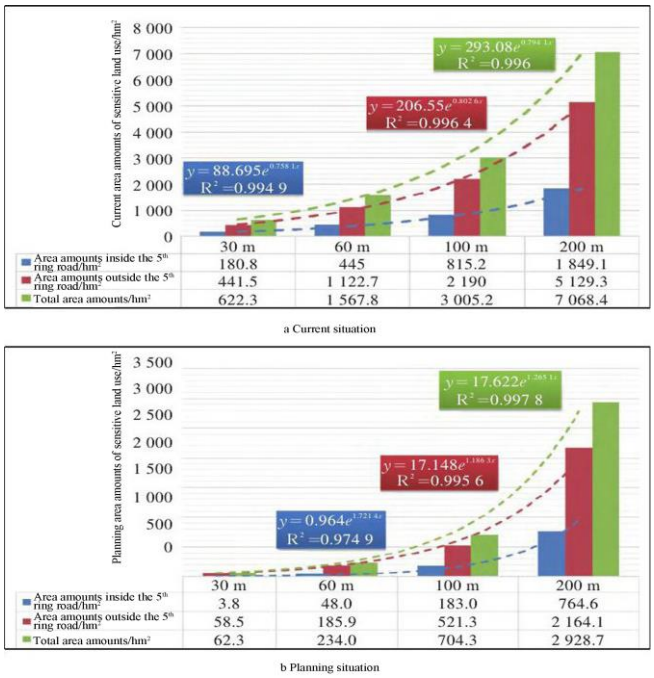

Figure 6 Sensitivity of land use in planning control areas along arterial railways

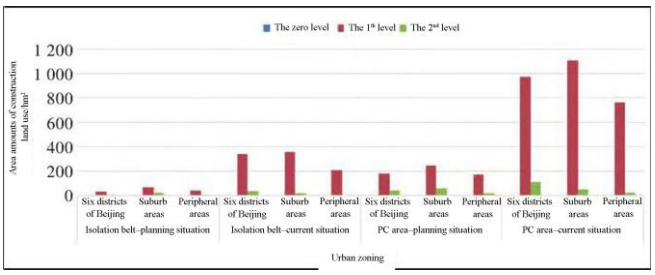

Figure 7 Land use statistics based on planning control indicators

According to the proposed PC methods, the area amounts of current construction land use according to the 1st type of sound environments in both the PC area and isolation belt are very large, with the suburb new towns exceeding 1 000 hm^2. Although the area amounts of planned construction land use inside the PC areas along ARs decrease sharply, the total amounts are still considerable large, about 700 hm^2 (See Figure 7). The suggestion is that the land use in both the isolation belt and PC area along ARs should be strictly supervised according to the proposed PC methods during the whole process of planning and construction of urban land use. The demolishment and planning implementation of the land use types according to the zero, the 1st and 2nd types of sound environments in the PC area should be coordinately fulfilled with the city construction plan.

5 Conclusions

The purposes of PC along ARs are to safeguard safety levels of railway operation, to settle countermeasures like decreasing noise, vibration and radiation, and to reserve spaces for landscape and capacity increase of existing AR corridors. A PC method of "Two Areas and Three Lines" along ARs is proposed. The PC boundaries and technical requirements for both AR and city construction are stated. Attentions should be paid that the PC area provides space for noise control along railways, but it is not effective enough for controlling the noise levels to a standard level to satisfy the requirements of environmental protection sectors. Meanwhile, the conception of ARPC focuses on land use control along ARs, with no confliction to the greening belt from the Landscape Sector, and the ARPC and greening belt can be coordinately implemented. Besides, there are numerous sensitive land use types inside PC areas along ARs due to historical reasons, which are not beneficial to the construction of a livable and enterprise-adaptable eco-city. Both important decisions from government sectors and supports from social public are urgently needed to promote the implementation of PC area along ARs.

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