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Sensory Design-Driven: Spatial Assessment of Pedestrian Landscapes in Railway Station Areas of Greater Bay Area

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Abstract: *This study aims to enhance the walking experience in TOD projects by using landscape design to optimise the walking environment. It explores the use of the senses of sight, sound, smell, touch, and taste to create a more immersive and delightful experience for pedestrians. Focusing on three prominent Transit-Oriented Development (TOD) projects in the Guangdong-Hong Kong-Macao Greater Bay Area: Hong Kong Central Station, Guangzhou East Station, and Shenzhen North Station, the study assesses the implementation and impact of five sensory designs in these three stations through on-site research. The study seeks to establish a comprehensive design framework for the initial and final sections of the rail transit pedestrian network in the Guangdong-Hong Kong-Macao Greater Bay Area. Its objective is to improve the overall experience of pedestrians in the vicinity of rail transit stations and support the sustainable development of urban areas within the Guangdong-Hong Kong-Macao Greater Bay (GBA) Area, providing practical insights for urban planners and professionals in the fields of architecture, urban design, and transportation.*

Keywords: *Sensory design; TOD; Pedestrian environment*

1. Introduction

Due to the rapid urbanisation, the Guangdong-Hong Kong-Macao Greater Bay Area is seeing a rise in both traffic congestion and environmental pollution issues. In light of this context, the idea of Transit Orientated Development (TOD) has arisen with the goal of enhancing the efficiency and sustainability of cities' transport systems. This is achieved by encouraging the use of public transport and decreasing the dependence on private vehicles through the implementation of high-density, multi-functional urban design strategies. Effective execution of Transit-Oriented Development (TOD) initiatives not only enhances traffic conditions but also enhances the overall well-being of city dwellers. The TOD idea emphasises the significance of integrating residential, office, commercial, and recreational activities around transportation hubs in order to optimise the utilisation of land resources. This methodology efficiently decreases both the time and distance of commuting while also enhancing the convenience and accessibility of public transit through the optimisation of the transport network. Transit-oriented development (TOD) prioritises human-centred design and promotes walking and cycling while minimising dependence on private vehicles. This approach effectively mitigates traffic congestion and environmental pollution, distinguishing it from conventional urban development patterns.

The significance of a high-quality pedestrian environment as a crucial connection between various transportation modes must be considered in TOD initiatives. The level of comfort and enjoyment when walking significantly influences individuals' inclination to opt for public transport, particularly in densely populated urban areas like the Guangdong-Hong Kong-Macao Greater Bay Area. By implementing rational urban planning and design, it is possible to create safe, convenient, and comfortable walking environments. This, in turn, can significantly improve people's travel experience and encourage the utilisation of public transportation. Simultaneously, the implementation of this human-centric design idea can contribute to the improvement of community cohesiveness and the overall pleasure of people, thereby fostering the advancement of sustainable urban development. Thus, in order to promote the implementation of TOD projects, it is necessary to carefully evaluate several issues, including transportation, the environment, and human habitation. Efficient management and scientific planning are essential to optimise the urban transport system in the Guangdong-Hong

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Kong-Macao Greater Bay Area. This will enhance the residents' quality of life and promote sustainable development in the region.

2. Literature Review

Transit-Oriented Development (TOD) has become a prominent focus in the realm of urban development and planning. TOD, or Transit-Oriented Development, seeks to enhance the coordination between public transportation and the surrounding land use. Its goal is to establish a densely populated, pedestrian-friendly, and versatile environment that encourages the use of public transit and decreases dependence on private vehicles [1]. Research has demonstrated that effective transit-oriented development (TOD) planning not only promotes the efficiency and appeal of public transportation systems but also improves the sustainability and overall quality of life in metropolitan areas [2]. Nevertheless, the current layout of pedestrian areas in transport hubs frequently prioritises practicality while disregarding the human experience and emotions, leading to unappealing and uncomfortable settings. Furthermore, the increased volume of individuals in transportation hub regions exacerbates issues such as noise pollution and inadequate air quality. These factors necessitate more stringent criteria for the landscape design of pedestrian zones [3].

Recently, there has been a growing trend in utilising sensory design in urban public spaces and architectural design. Sensory design is a holistic approach that takes into account people's visual, aural, olfactory, tactile, and gustatory senses [4]. By prioritising the multi-sensory experiences of individuals, the implementation of a five-sensory design can enhance the comfort and enjoyment of walking surroundings. Consequently, this can serve as a motivational factor for individuals to opt for walking and utilising public transportation more frequently [5]. For instance, visual design can improve the brightness and visual attractiveness of a space by using suitable lighting and colour schemes. Auditory design can create a calmer environment by incorporating natural sounds and managing noise levels. Olfactory design can enhance the enjoyment of space by incorporating aromatic plants or introducing appropriate fragrances. Haptic design can heighten the tactile experience of space by utilising various materials and textures in the floors and furniture. Lastly, gustatory design can enhance the tactile experience of a space by emphasising multi-sensory experiences. The inclusion of cafes or snack shops along a walking path can improve the duration and intensity of pedestrians' experiences by including elements of taste and design [6].

The strategic integration of five-sense design elements in TOD projects within the Guangdong-Hong Kong-Macao Greater Bay Area can significantly improve the appeal of public transport stations and their surrounding areas, as well as enhance the overall quality of life and sustainability of the region [7]. The region, being a swiftly progressing urban conglomeration, encounters issues such as traffic congestion, environmental pollution, and limitations in land resources. Hence, implementing a five-sense design in TOD projects can significantly enhance the pedestrian environment, encourage greater utilisation of public transportation, and consequently decrease reliance on private vehicles, thereby alleviating traffic congestion and mitigating environmental impact. Furthermore, the use of five-sense design has the potential to improve the quality of public spaces in metropolitan areas, fostering a stronger sense of community and belonging among people [8].

To summarise, using five-sense design in TOD projects not only aligns with the "human-centred" approach in contemporary urban planning but also enhances the quality of urban public spaces and fosters sustainable development. Implementing the five-sense design is crucial and visionary, especially in quickly developing regions like the Guangdong-Hong Kong-Macao Greater Bay Area [9].

3. Research Design

3.1 Case Selection

This study focuses on three selected Transit-Oriented Development (TOD) projects in the Greater Bay Area of Guangdong, Hong Kong, and Macao. The case study objects include Hong Kong Central Station, Guangzhou East Station, and Shenzhen North Station. Each of the three stations possesses distinct features in terms of size and intricacy of design, exemplifying various forms of Transit-Oriented Development (TOD) initiatives in the Greater Bay Area. The Central Station is situated in the central business district of Hong Kong, whereas the Guangzhou East Station and Shenzhen North Station function as crucial transportation hubs linking Guangdong, Hong Kong, and

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Macao. This showcases the successful execution of Transit-Oriented Development (TOD) initiatives in diverse urban settings. The chosen stations not only encompass the key cities in the Greater Bay Area in terms of geography but also have an eclectic variety of services related to commerce, transportation, and leisure. This makes them a valuable source of data for research purposes. The locations cater to a large number of commuters, travellers, and tourists every day. The wide range of users assures that the data obtained may effectively represent the requirements and sentiments of many groups of people regarding the experience of walking in TOD areas.

3.2 Data Collection

Field visits were done at specific Transit-Oriented Development (TOD) projects to identify and assess various design features, such as paving materials, lighting, greenery, guidance signs, plants, and flower scents, in the pedestrian environment of these locations. The study employed non-participatory observation, where the researcher acted as an external observer and did not directly participate in the scenario. The researcher recorded scores for each observation on a scale of 0-10. A score of 0 indicated that the item was not considered or poorly executed. In contrast, a score of 10 indicated that the item was adequately considered and well executed in the project, as illustrated in Table 1. The rating criteria encompass the design's level of inventiveness, practicality, compatibility with the surrounding environment, and its ability to attract and satisfy the intended user group. Points of interest encompass users' navigation routes, locations where they pause, responses to specific design components, and so on. Photography and video recording technologies were utilised, where allowed, to document significant ambient characteristics and user actions for further examination.

Table 1: Evaluation Scale for Perception of Walking Space, Based on Sensory Design

Category	Code	Description
Visual experience	F1	Suitability of light intensity
	F2	Safe and comfortable lighting atmosphere
	F3	Attractive night lighting
	F4	Harmonious and regional use of colours and materials
	F5	Comfortable material choices
	F6	Green coverage
	F7	Clear and easy-to-understand guidance signs
	F8	Visually friendly guidance for pedestrian movement
	F9	Integration of local art and cultural elements
	F10	Spatial attractiveness of public art installations
Auditory experience	F11	Presence of natural sounds
	F12	Contribution of artificial sound sources to the listening experience
	F13	Measures to reduce traffic and industrial noise
Olfactory experience	F14	Selection and seasonal variation in the use of scented plants
	F15	Air quality in the walking area
	F16	Avoidance of undesirable odours and pollutants
Tactile experience	F17	Materials and surfaces F20 Smoothness and accessibility of walking surfaces
	F18	Materials and design of public seating and railings
	F19	Installation of tactile interactive devices or facilities
Taste experience	F20	Food diversity and quality satisfaction

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4. Data Analysis

An analysis was conducted to assess the 800-meter walking environment around three major rail transit stations in the Guangdong-Hong Kong-Macao Greater Bay Area: Hong Kong Central Station, Guangzhou East Station, and Shenzhen North Station. The analysis focused on five categories of experience: visual, auditory, olfactory, tactile, and gustatory. The purpose was to evaluate the stations' performance and findings based on these different experience factors.

A comparative analysis of user satisfaction was conducted among Hong Kong Central Station, Shenzhen North Station, and Guangzhou East Station, focusing on the F1 to F20 categories. As indicated in Figure 1, the Y-axis corresponds to the evaluation ratings, while the X-axis enumerates 20 distinct features or elements (F1-F20) that impact the pedestrian and station experience.

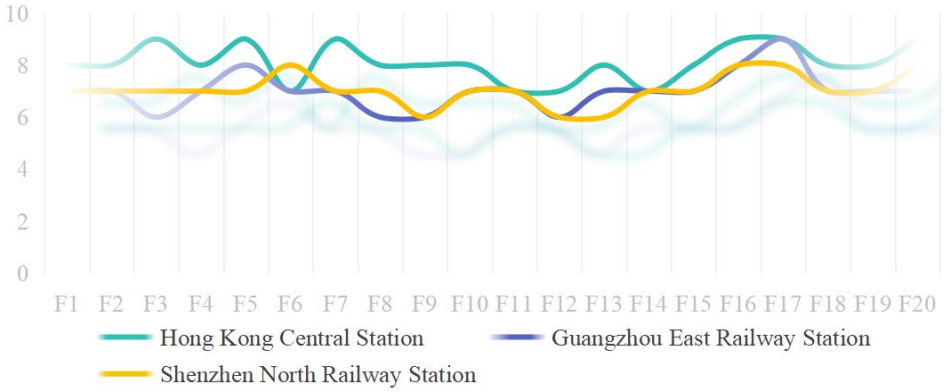

Figure 1: Sensory experience factor score curve

4.1 Multi-dimensional assessment of the walking environment

4.1.1 Visual experience

The lighting and illumination of Hong Kong Central Station, namely in areas F1, F2, and F3, are designed to be exceptional. The nighttime lighting is not only visually appealing but also contributes to a heightened sense of safety and comfort for pedestrians. Guangzhou East Station and Shenzhen North Station performed at superior levels in terms of light intensity and uniformity. At the same time, they lacked a unique night-time lighting design and needed to be more visually appealing compared to Central Station.

The Central Station excels in its colour matching and material selection, showcasing high-quality texture and meticulous colour coordination. Guangzhou East Station prioritises functionality and long-lasting quality, whereas Shenzhen North Station is somewhat traditional in its selection of hues and materials and lacks visually striking features.

Central Station increases the visual experience by incorporating abundant artistic and cultural components, which in turn attracts a substantial number of both residents and tourists. On the other hand, the art and cultural aspects of Guangzhou East Station and Shenzhen North Station are comparatively restricted. The number and calibre of art installations are inferior to those seen at Central Station, resulting in a lack of visual impact.

4.1.2 Auditory experience

The Central Station excels in its ability to introduce natural sounds and handle artificial sound sources, resulting in a harmonious auditory experience with a well-balanced blend. However, the auditory comfort of the walking areas in Guangzhou East Station and Shenzhen North Station was compromised due to the insufficient optimisation of artificial sound sources and lack of control over background noise.

4.1.3 Olfactory experience

Plants and Floral Scent (F14): Shenzhen North Station performs well in terms of plant selection and seasonal changes. The walking area has a wide variety of scented plants, providing an excellent olfactory experience. Guangzhou East Station and Central Station perform similarly in this regard, with a slight lack of variety and distribution of scented plants, although both have some plant cover.

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Air Quality (F15, F16): Central Station has the best air quality, thanks to the effective control of pollutant sources and management of undesirable odours. The air quality of Guangzhou East Station and Shenzhen North Station is slightly lower, but the overall performance is good, providing a relatively fresh air environment for walkers.

4.1.4 Haptic experience

The walking surfaces and barrier-free design of Central Station and Guangzhou East Station in the Materials & Surfaces (F17) category were commendable, ensuring a comfortable pedestrian experience with their excellent flatness. Shenzhen North Station demonstrated commendable performance in this regard. However, the tactile qualities and design ingenuity of the surface materials could have been better compared to those of Central Station and Guangzhou East Station.

Furniture and Facilities (F18, F19): Central Station prioritises ergonomics when designing public seats and railings and offers a variety of tactile and interactive amenities to enhance the overall pedestrian experience. Both Guangzhou East Station and Shenzhen North Station exhibit similar performance in this aspect, although they need more creativity and diversity.

4.1.5 Taste experience

Food Diversity and Quality (F20): The Central Station offered a diverse range of high-quality food and drink options that catered to the preferences of many groups of people. This greatly enhanced the overall experience of the pedestrians by providing a satisfying taste experience. Guangzhou East Station has a limited range of eating choices, yet it still manages to give some degree of variety. Conversely, Shenzhen North Station exhibits local tastes by offering a range of local delicacies. However, the total assortment and excellence could be much better than that of Central Station.

4.2 Relationships and contributions between sites and assessment factors

To illustrate the distribution of factors (F1 to F20) for three railway stations, namely Hong Kong Central Station, Guangzhou East Station, and Shenzhen North Station, Figure 2 presents a Sankey diagram. The relative thickness of the links between stations and factors reflects the level of correlation or impact of each factor at these specific stations.

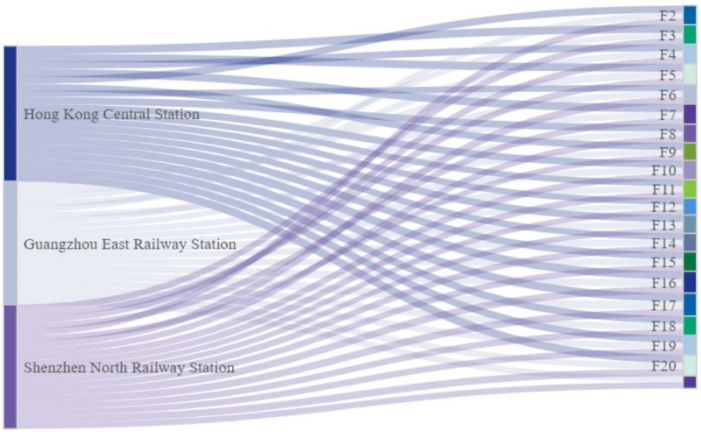

Figure 2: Correlation between railway locations and evaluation criteria

4.2.1 Performance evaluation

The flow of people in Hong Kong Central Station is dense and widely distributed, indicating a high level of performance across various factors. Notably, the station excels in aspects related to visual and tactile experience. This suggests that the overall performance of Central Station is well-balanced and comprehensive.

The Guangzhou East Station exhibits a moderate density of related flows, suggesting a relatively balanced performance without any exceptional achievements. The overall contribution is evenly distributed but needs more brilliance.

The correlation flow at Shenzhen North Station is characterised by a low and uneven pattern, indicating its superior performance in certain aspects, such as F6 Green Coverage and F16 Air Quality, but a comparatively weak performance in other factors, resulting in a significant imbalance.

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4.2.2 Strengths of the stations

Central Station is highly correlated with several aspects due to its diverse and exceptional performances, particularly in terms of F5 (the texture and selection of pleasant materials) and F10 (the visual appeal of public art pieces in the space).

Guangzhou East Station demonstrates a satisfactory performance across various aspects, particularly in terms of F7 (the presence of clear and comprehensible guidance signs) and F17 (the evenness and ease of access to walking surfaces). However, it lacks strong linkages with factors relating to art and cultural features.

Shenzhen North Station stands out in Greening (F6) and Air Quality (F16), indicating its superior environmental friendliness. However, it has restricted performance in other aspects, such as Lighting and Artistic Elements.

4.2.3 Weaknesses and potential for improvement

Despite its overall outstanding performance, Central Station exhibits a weak correlation with specific olfactory-related parameters, such as the F14 Plant and Flower Scent. This implies that there is room for further improvement in this particular area.

The overall performance of Guangzhou East Station is satisfactory, indicating that its general appeal can be improved by enhancing the design of specific features, such as F3 Attractive night-time lighting and F9 Integration of local art and cultural elements.

Shenzhen North Station should focus on enhancing the visual and tactile experience by improving aspects such as F4 (colour coordination) and F19 (tactile interactive devices). This would help to enrich and diversify the overall sensory experience at the station.

5. Conclusions

Based on comprehensive analyses of the walking environments at three major rail transit stations - Hong Kong Central Station, Guangzhou East Station, and Shenzhen North Station - the following conclusions have been drawn. These conclusions highlight the variations in the visual, auditory, olfactory, tactile, and gustatory experiences, as well as the overall significance of the sensory experience at the stations. The findings are as follows:

5.1 The crucial significance of the visual encounter

The visual experience plays a crucial role in the walking environment, significantly influencing the walker's perception of safety, comfort, and spatial appeal. The Hong Kong Central Station boasts a meticulously crafted lighting system, a cohesive colour palette, and an abundance of artistic and cultural aspects that significantly elevate the overall visual ambience of the region. Central Station utilises high-quality visual design to not only offer functional lighting but also to draw in a significant number of pedestrians at night through the artistic presentation of lights, thus improving the appeal of the region.

Guangzhou East Station and Shenzhen North Station, although they have good essential light intensity and lighting uniformity, need visual highlights, particularly in terms of night-time lighting design and integration of artistic elements. This makes them slightly less visually appealing compared to the Central Station. Thus, it is recommended that these two stations boost their visual allure by bolstering the nocturnal illumination scheme and incorporating artistic and cultural components in order to entice more pedestrians and extend the duration of their visit.

5.2 Sound perception and comfort in the environment

The auditory experience directly influences the psychological well-being of those who are walking. Hong Kong Central Station demonstrates exceptional performance in this particular category. By implementing efficient noise reduction measures and incorporating soothing natural sounds, Central Station offers a tranquil and lively atmosphere for pedestrians. Integrating natural sounds, such as the gentle flow of water and the melodic chirping of birds, effectively reduces the tension experienced by walkers and improves the overall comfort of their walking experience.

Guangzhou East Railway Station and Shenzhen North Railway Station demonstrate satisfactory performance in terms of auditory experience, while there is potential for enhancement, particularly in

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managing artificial sound sources and controlling background noise. In the future, these stations could investigate incorporating natural sounds and fine-tuning the placement of synthetic sound sources to minimise noise disruption for pedestrians and enhance the overall auditory experience.

5.3 Potential for improving the olfactory experience

The sense of smell plays a significant role in the pedestrian environment, yet it is frequently disregarded. The Shenzhen North Railway Station stands out in this region, particularly in its selection of flora and the dynamic variations of fragrant plants throughout the seasons. By cultivating a variety of aromatic plants, Shenzhen North Station enhances air quality and offers a delightful olfactory experience for pedestrians.

Nevertheless, Hong Kong Central Station and Guangzhou East Station's performance in this regard could be better. While these two stations demonstrated satisfactory performance in air quality control, there is still potential for enhancement in the variety and dispersion of fragrance-producing flora. It is advisable to enhance the olfactory experience by incorporating a wider variety of fragrant plants and strategically altering their presence according to the seasons. This will allow walkers to indulge in a more excellent range of natural fragrances during their strolls.

5.4 Tactile sensation and comfort for pedestrians

The physical comfort of pedestrians is directly influenced by the tactile experience they have with walking surfaces and the design of public facilities. The Hong Kong Central Station and Guangzhou East Station are equipped with level walking surfaces and well-designed barrier-free facilities, ensuring a comfortable and secure walking environment for pedestrians. Furthermore, the inclusion of ergonomically built public chairs and plentiful tactile interactive facilities enhances the tactile experience for pedestrians, so creating a more amiable and user-friendly walking environment.

While Shenzhen North Station provides a satisfactory tactile experience, it needs to improve the quality of the flooring materials and the level of innovation in its tactile interactive features, especially compared to Central Station and Guangzhou East Station. Future enhancements can be made to improve the tactile experience of walkers by incorporating more comfortable and novel material designs.

5.5 Variety and excellence of sensory perception

The taste experience dramatically influences the overall appeal of the walking environment, particularly in areas that involve dining and socialising activities. Hong Kong Central Station excelled in this aspect, providing a diverse selection and high standard of food choices that effectively met the preferences of various demographics. This not only enhances the amount of time pedestrians spend in the neighbourhood but also fosters more prospects for social engagement.

While Guangzhou East Station and Shenzhen North Station may provide a different level of variety in food and beverage options than Central Station, they nonetheless offer appealing cuisine selections. In particular, Shenzhen North Station stands out for its unique local taste, with a choice of regional specialities. In the future, the two stations have the potential to enhance the appeal of the taste experience by expanding the variety of dining options and improving the quality of the cuisine.

In conclusion, in order to improve the walking experience, the sites should focus on enhancing the variety of sensory experiences, optimising control over noise and air quality, strengthening visual and tactile design, and enriching the taste experience. This will create a more pleasant, enjoyable, and appealing walking environment for pedestrians. This would not only improve the quality of life in the area but also stimulate the vitality and economic growth of the Guangdong-Hong Kong-Macao regional city cluster area.

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