Transit Oriented Development (TOD) typology

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Abstract. Transit-Oriented Development (TOD) Typology is becoming increasingly significant as our planet urbanises. It promotes an environmentally sustainable development, eases mobility, increases real estate value, encourages healthy lifestyles with activities such as walking, and improves neighbourhood through place-making by making it safer. In short, TOD Typology makes a city worth staying in. Although there are a number of studies available, TOD which primarily focuses on developing countries is still undiscovered. This research paper aims to identify the TOD indicators and the mechanism of inter-modal stations to integrate various modes of transport in Bandar Penggaram, Batu Pahat. The method used in this research was mixed method using a survey, observation, and document review to obtain accurate data. A survey was conducted by distributing questionnaires to 370 respondents. The observation was carried out by assessing using a checklist in the research area. Meanwhile, the document review was conducted based on the document obtained from Majlis Perbandaran Batu Pahat (MPBP). Through the data analysis of the checklist assessment and document review regarding the identification of TOD indicators and mechanism of intermodal station via the SPSS software, the results indicated that density, land use, walkability and cyclability, access and accessibility, interchange stations and system integration are deemed suitable and have a great potential to improve the development of TOD typologies. These elements are useful and provide benefits to passengers or users, pedestrians, and cyclists. This paper would be beneficial as it provides a new insight and guidance for the government and the authorities to improve current practices and also for future research to conduct similar studies related to TOD typology.

Keywords. Transit Oriented Development (TOD), typology, indicator, inter-modal, station

1. Introduction
TOD typology can be defined as an alternative to group together different transit zones that have a common set of characteristics. A typology has several place types, and all of the station areas within one place type have some elements in common. The characteristics that define a typology can differ depending on what outcomes the typology are meant to accomplish. Nonetheless, not every station area in one place type will be exactly the same. Typologies are useful tools because they increase understanding of characteristics that contribute to a place, establish measurable performance benchmarks, and provide a framework to set goals for better performance [1]. There are a few types of TOD typologies in Malaysia, such as Urban TOD, Urban Neighbourhood TOD, Sub Urban...
Neighbourhood TOD, and Neighbourhood TOD. However, there are also several types of existing TOD typologies such as Town Centre TOD, Neighbourhood Medium TOD, Neighbourhood Low Density, and High Frequency Transit Corridor TOD typologies which have already been practiced in other countries.

In Malaysia, a lot of efforts and incentives by the Malaysian policies related to TOD were constructed under the 10th Malaysian Plan RMK-10 (Chapter 6: Building An Environment That Enhances Quality Of Life), National Physical Plan (NPP), National Urban Plan (NUP), and Draft Planning and Design Guidelines for Compact and Liveable Development. These are to encourage the use of public transportation, walking, and cycling as alternatives to the main modes in this development [2]. For example, Kuala Lumpur Sentral is one of the places in Malaysia which has applied the TOD typology concept, i.e., Urban TOD. Kuala Lumpur Sentral is an exclusive urban centre in the area of Brickfields, which was built around Malaysia’s largest transit hub. Besides public transport, its TOD development consists of a residential area, office blocks, hotels, shopping malls, an international exhibition centre, and entertainment outlets. The 72-acre project was designed by the late Dr. Kisho Kurokawa. The project commenced in 1997 and was planned to be completed by 2015 [3].

Plus, the limited space within the high-density area is one of the main factors that affects the TOD concept which is to be built within certain areas in Malaysia. This happened due to the development of residential buildings and offices. The development of TOD typology is important as its philosophy promotes a multifunctional building which integrates various kind of facilities. Most of the previous research on the development of TOD typology did not provide enough data and were conducted in other countries which have different characteristics compared to cities in Malaysia. So far, there is a lack of studies that systematically develop a TOD typology in Malaysian context. Therefore, this research was conducted as there was no research regarding TOD at Bandar Penggaram. It was also meant to fill the gap in the previous research and highlight the literature on integration of land use and transport a key feature of the transit-oriented development by complementing the node-place model with an evaluation on the connectivity of station areas in Bandar Penggaram, Batu Pahat, Johor.

This paper used Transit-Oriented Development (TOD) Typology. The first section of this paper determines TOD problems while the second section reviews several relevant past studies. The third section discusses the research methodology, data sources, and model specification. The fourth section analyses the results of the survey, and the fifth section provides the conclusions and implications of this study.

2. Materials and Method
This section details methods which were conducted throughout the research. These include the procedures that were used, the methods, as well as the data and software involved in data analysis. The data in this paper were spatial and attributes. The collected data were obtained from the Batu Pahat Municipal District, ministry, and previous researches. These were expected to support the processes in this study.

2.1. Quantitative Approach
Quantitative approach was as the data were obtained through a survey and an observation within the area involved. The observation was assessed against a checklist of existing TOD indicators and mechanisms of intermodal station to achieve the research objectives. Besides that, a survey was also carried out. Questionnaires related to TOD were answered by the passengers or the users of the transit stations such as pedestrians as cyclists, as well as other users who used any of the routes involved.

2.2. Qualitative Approach
A qualitative approach was used to collect the qualitative data which was a document review regarding the research area. The qualitative data were analysed. The data too strengthened other collected data as the researcher had gone to the fieldwork and observed the real situation within the area.
2.3. Sampling and Population Technique
Population is a collection of individuals or objects that have similar characteristics. All individuals or objects within a certain population usually have common, binding characteristic or trait. Majlis Perbandaran Batu Pahat (MPBP) stated that the population of residents living in Bandar Penggaram, Batu Pahat in 2020 was 75, 148; it defines the higher density of population in Bandar Penggaram. Firstly, the population was defined, which is expressed as N. Next, the sample size was chosen based on the Krejcie and Morgan Table, which is expressed as S. The third step was to list the population based on the targeted respondents. In this research, the target respondents were the users of 11 roads involved, which include the residents, pedestrians, transit users or passengers, and cyclists. Then, the survey were distributed randomly to the respondents. The data obtained were then analysed.

3. Result and Discussion
The analysis of the data and the results of the research were based on mixed-method approach which was deemed suitable for this research. In this study, the approach was used to achieve the objectives. Based on the objectives, the survey was carried out by distributing questionnaires among the targeted respondents. The data obtained were then analysed using Statistical Package for Social Science (SPSS) which expressed the data in the form of tables. Also, an observation was conducted at the research area in Bandar Penggaram by assessing against a checklist of the existing Transit-Oriented Development (TOD) indicators. Moreover, a document review was performed to obtain further information regarding the development of Transit-Oriented Development in Bandar Penggaram.

3.1. Questionnaire Result
From the analysis, it was found that the total number of respondents was 250 which majority of them were females with a total number of 145, Meanwhile the remaining are males, i.e., 105. Majority of the respondents were within the age range between 21 to 25 years old, followed by another age range. It was found that majority of the respondents were Malays with the percentage of 48.6%, 32.8% of Indians, and 18.5% of Chinese. Despite that, one of the respondents was a Siamese. The targeted respondents were the residents of 11 roads in Bandar Penggaram, Batu Pahat, Malaysia. The roads were chosen as they are situated in the Low Carbon Cities Framework (LCCF) zone in Batu Pahat. The LCCF zone is included in the future infrastructure and town planning of Batu Pahat towards being one of the low carbon cities in Malaysia.

Table 1. Result of survey questions

|                          | Frequency | Percent |
|--------------------------|-----------|---------|
| **TOD 1: Know TOD**      |           |         |
| Yes                      | 107       | 42.8    |
| No                       | 59        | 23.6    |
| Maybe                    | 84        | 33.6    |
| **TOD 2: Know Utilization of Existing TOD** | | |
| Yes                      | 119       | 47.6    |
| No                       | 88        | 35.2    |
| Maybe                    | 43        | 17.2    |
| **TOD 3: TOD Criteria**  |           |         |
| Transit Station          |           |         |
| Unselected               | 36        | 14.4    |
| Selected                 | 214       | 85.6    |
| Shopping Centre          |           |         |
| Unselected               | 107       | 42.8    |
| Selected                 | 143       | 64.4    |
| Residential Area         |           |         |
| Unselected               | 89        | 35.6    |
| Selected                 | 161       | 64.4    |
| Commercial Centre        |           |         |
| Unselected               | 101       | 40.4    |
| Selected                 | 149       | 59.6    |
| Cycling Way              |           |         |
| Unselected               | 100       | 40.0    |
| TOD 4: Factors Affect Utilization TOD | Selected | Unselected | Percentage |
|-------------------------------------|----------|------------|-------------|
| Pedestrian Walkway                  | 150      | 69         | 60.0        |
|                                     | 181      |            | 72.4        |
| Near to residential area            |          | 108        | 43.2        |
|                                     |          | 142        | 56.8        |
| Near to workplace                   |          | 130        | 52.0        |
|                                     |          | 120        | 48.0        |
| Traffic congestion                  |          | 139        | 55.6        |
|                                     |          | 111        | 44.4        |
| Cost-saving                         |          | 132        | 52.8        |
|                                     |          | 118        | 47.2        |
| Save time                           |          | 156        | 62.4        |
|                                     |          | 94         | 37.6        |
| Public transportation               |          | 140        | 56.0        |
|                                     |          | 110        | 44.0        |
| Interchange station                 |          | 164        | 65.6        |
|                                     |          | 86         | 34.4        |
| Cycling way                         |          | 130        | 52.0        |
|                                     |          | 120        | 48.0        |
| Pedestrian Walkway                  |          | 119        | 47.6        |
|                                     |          | 131        | 52.4        |

| TOD 5: Know Intermodal Station      | Yes      | 50         | 20.0        |
|                                     | No       | 173        | 69.2        |
|                                     | Maybe    | 27         | 10.8        |

| TOD 6: Characteristics That Determine a Systematic Intermodal Station | Unselected | Selected | Percentage |
|---------------------------------------------------------------------|------------|----------|-------------|
| Has interchange station                                            | 83         | 167      | 33.2        |
| Good system integration                                            | 77         | 173      | 30.8        |
| Well facilitated                                                   | 80         | 170      | 32.0        |
| Accessibility                                                       | 86         | 164      | 34.4        |
| Cyclist and pedestrian friendly                                    | 93         | 157      | 37.2        |
|                                                                      |            |          | 62.8        |

| TOD 7: Satisfactory Towards Existing TOD                           | Not satisfied | 3         | 1.2         |
|---------------------------------------------------------------------|---------------|-----------|-------------|
| Not satisfied because lack of facilities such public toilet, prayer room and waiting area. | 1              | 0.4       |
| Not satisfied because it feels unsecured and dangerous to go upper floor of the terminal. | 1              | 0.4       |
| Not satisfied, because the existing public transportation system is not systematic. | 1              | 0.4       |
| Not satisfied, the facilities need to be improved.                  | 1              | 0.4       |
| Not satisfied                                                      | 1              | 0.4       |
| Satisfied                                                           | 4              | 1.6       |
| Satisfied because the existing development provide good services towards users. | 1              | 0.4       |
| Satisfied but need more improvement.                               | 2              | 0.8       |
| Satisfied but rearrange bus schedule for passengers to plan their journey. | 1              | 0.4       |
| Satisfied, because it is time saving.                              | 1              | 0.4       |
Satisfied, but need to increase more public transport.
Satisfied. Because it provides bicycle ways, however the safety measures need to be concern.
Satisfied. Most facilities are well oriented in terms of time saving and operation.
Satisfied. The facilities may not well-facilitated, but still can be used.

## TOD 8: Suggestion for Local Authorities Regarding TOD Improvement

| Suggestion | Frequency | Confidence |
|------------|-----------|------------|
| Authorities should plan for a transport network that can reduce traffic congestion. | 1 | 0.4 |
| Build more multifunctional building consistently to fulfil public needs. | 1 | 0.4 |
| Collaborate with more company that develop good infrastructure in Bandar Penggaram. | 1 | 0.4 |
| Collaborate with private sector to improve the facilities. | 1 | 0.4 |
| Conduct a survey based on community perspective so that the authorities can make improvement. | 1 | 0.4 |
| Conduct more research to improve the public facilities due to the increasing number of populations | 1 | 0.4 |
| Control the speed limit in the road that have bicycle way. | 1 | 0.4 |
| Improve facilities and hold awareness campaign. | 1 | 0.4 |
| Improve more facilities rather than build more TOD. | 1 | 0.4 |
| Improve the development and facilitate more secured and comfortable facilities such as toilet. | 1 | 0.4 |
| Improve the facilities and secure the place under surveillance for safety. | 1 | 0.4 |
| Improve the facilities for pedestrians. | 1 | 0.4 |
| Improve the facilities of the existing station and add more stations. | 1 | 0.4 |
| Improve the quality of the facilities and provide more accessibility public transportation. | 1 | 0.4 |
| Keep observe how TOD works on customers in Bandar Penggaram. | 1 | 0.4 |
| Provide a good system for public transport. | 1 | 0.4 |
| Provide more comfortable prayer room, public toilet and well facilitated waiting space. | 1 | 0.4 |
| Provide more transit point and increase punctuality of public transport | 1 | 0.4 |
| Replace because most of the facilities were damaged. | 1 | 0.4 |
| The involved authorities need to plan more improvements for facilities so that the users can use. | 1 | 0.4 |
The public transport needs to be well facilitated with good infrastructure planning.

3.2. Observation Result

An observation was carried out in the research area at Bandar Penggaram to assess against a checklist of Transit-Oriented Development (TOD) indicators as part of data collection for this research. The purpose of the observation was to achieve the objectives of the research. Besides, the data obtained can be used to propose further improvement of the research area to achieve the LCCF objectives. The observation checklist that were used for the data collection consists of a list of TOD indicators such as density, land use, walkability and cyclability, access and accessibility, interchange station, and system integration with a list of 11 roads that were chosen as the research area. As shown in Table 3.2, the structure of the observation checklists was constructed based on the existing TOD indicators and mechanisms of intermodal station, such as Density, Land Use, Walkability and Cyclability, Access and Accessibility, Interchangeability, and System Integration.

| Sultanah | Rahmat | Mohd | Zabedah | Pejabat | Ampuan | Zarahah | Tanjong | Masjid | Syahbandar | Muhammad | Akil |
|----------|--------|------|----------|---------|--------|---------|---------|--------|-------------|----------|------|
| 1        | 0.4    |      |          |         |        |         |         |        |             |          |      |

Table 2. Observation Checklist

(a) TOD Indicator: Density

- Population density
  - High
  - High
  - Medium
  - High
  - Medium
  - Medium
  - High
  - Low
  - Medium
  - High

(b) TOD Indicator: Land Use/ Mixed Use

- Residential area
  - No
  - No
  - No
  - Yes
  - No
  - Yes
  - Yes
  - Yes
  - No
  - Yes

- Industrial/ Commercial area
  - Yes
  - Yes
  - Yes
  - Yes
  - Yes
  - Yes
  - Yes
  - No
  - Yes

(c) TOD Indicator: Walkability and Cyclability

- Cyclist-friendly paths connected to public transport stations
  - No
  - No
  - No
  - No
  - Yes
  - No
  - Yes
  - No
  - No
  - No

- Pedestrian-friendly walkways connected to public transport stations
  - Yes
  - No
  - No
  - No
  - Yes
  - No
  - Yes
  - No
  - No
  - No

(d) TOD Indicator/ Mechanism Intermodal Station: Access and Accessibility (From Road to Public Transport / Transit Station)

- Accessibility by:
  - Public Transport
  - Private Motorised
  - Bicycle
  - Walking

- Accessible Facilities:
  - Well-covered walkways
  - Bicycle parking
  - Security surveillance within the bicycle path and walkways area.

- Accessible Facilities:
  - Yes
  - Yes
  - No
  - Yes
  - No
  - Yes
  - No
  - Yes
  - No
  - Yes

- Accessible Facilities:
  - No
  - No
  - No
  - Yes
  - No
  - No
  - No
  - No
  - No
  - No

- Accessible Facilities:
  - No
  - No
  - No
  - Yes
  - No
  - No
  - No
  - No
  - No
  - No

- Accessible Facilities:
  - Yes
  - No
  - Yes
  - No
  - Yes
  - No
  - No
  - Yes
  - No
  - No
From the observation, the data were assessed with the TOD indicators and mechanisms of intermodal station in order to determine which of the roads in the research area has the most TOD indicators which is also suitable to integrate various modes of transports besides proposing the best road for future development of Transit-Oriented Development.

4. Conclusion

Based on the findings, the results were all compared to achieve the research objectives. According to the data analysis of the survey made, the respondents tended to focus on the improvement of facilities in the TOD area as some of the existing facilities need to be repaired. The tendency for the users or residents of Bandar Penggaram to utilise the facilities is high due to a few factors as mentioned in the results. To justify, the utilisation of Transit-Oriented Development can be maximised in Bandar Penggaram with specific initiatives, such as public transport, pedestrian roads, pedestrian walkways with bicycle paths in order to achieve the objectives of the Low Carbon Cities Framework. In conclusion, the initiatives must be well-planned and follow all the principles and strategies of the TOD which are to develop compact, walkable, as well as mixed-use communities around public transportation nodes, such as rail stations and major bus lines.

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