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International Journal of Physical Sciences and Engineering Available online at www.sciencescholar.us Vol. 7 No. 2, August 2023, pages: 11-22 e-ISSN : 2550-6943, p-ISSN : 2550-6951 https://doi.org/10.53730/ijpse.v7n2.14452 1 Analysis of the Model of Integrated Utilities Network Provision and Infrastructure in Denpasar City Made Sudiarsa a, I Wayan Sudiasa b, I Gede Sastra Wibawa c, I Ketut Sutapa d Manuscript submitted: 27 May 2023, Manuscript revised: 18 June 2023, Accepted for publication: 09 July 2023 Corresponding Author a Abstract The utility network serves as a crucial support system for fulfilling the various needs of a city, encompassing cable and pipe networks for electricity, clean water, waste management, telecommunications, and other essential services. However, the installation of utility networks has often been lacking in coordination, resulting in frequent disassembly and reinstallation. Given these circumstances, the objective of this research is to provide valuable insights and ideas to the government regarding the model of Integrated Utility Network Facilities, along with effective implementation methods and accurate construction cost estimation. This will be done while considering the presence of existing facilities and infrastructure. The research employed a quantitative descriptive method, utilizing a case study approach focusing on several roads in the city center as a pilot project. The objective of implementing integrated utility networks and infrastructure (ducting utilities) in Denpasar City is to establish coordination among agencies responsible for underground network utilities. The goals include maintaining a neat, orderly, and clean city environment, facilitating easier and more cost-effective network maintenance, avoiding damage or interference caused by third-party works, enabling information sharing in the event of network damages, and promoting environmental friendliness. Based on the analysis results, it can be inferred that the recommended design model for integrated utility network facilities and infrastructure (utility ducting) in Denpasar City is a top-bottom precast concrete box culvert model with dimensions of 1400 x 1800 x 1200. Keywords infrastructure; integrated; model; network; utilities;

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e-ISSN : 2550-6943 p-ISSN : 2550-6951 IJPSE Vol. 7 No. 2, August 2023, pages: 11-22 12

Contents

1 Introduction

Denpasar City, situated as the capital of Bali Province, serves as a significant hub for government, education, and economy. Its strategic location acts as the primary attraction for population migration to Denpasar City. The growth of a city can be observed through the consistent rise in its population, leading to increased social and economic activities within the city (Arsyad, 2004). The growth in these activities must be directly proportional to the development of infrastructure since the urban infrastructure is a direct result of urban spatial planning, which aims to facilitate the residents of the city in conducting their daily activities. The infrastructure system can be defined as the fundamental facilities, structures, equipment, and installations that are built and necessary for the functioning of the social and economic systems of society (Grigg & Darrel, 2000). The development of infrastructure, particularly in the form of utility networks, needs to be carefully coordinated to ensure the preservation of the interests of various stakeholders. Utilities encompass facilities that are of public interest, such as electricity, telecommunications, information, water, oil, gas, sanitation, and other energy sources (PP 34/06, 2006) Hence, it is essential to manage infrastructure effectively to ensure its continuous and sustainable functioning, while also considering economic and operational efficiency (Suprayitno & Soemitro, 2018). However, in reality, the opposite scenario is often observed, where the installation of utility networks lacks proper coordination, resulting in frequent disruptions and the need for dismantling recently completed road repairs due to utility installations. Restoring the road conditions to their original state often cannot be optimally executed, leading to accelerated road deterioration compared to the planned design life (Sari & Rudiarto, 2018). Considering these circumstances, this research aims to provide an evaluation of utility network management in several selected locations that are deemed as priorities or potential pilot projects in Denpasar City. The evaluation will focus on the implementation of Integrated Utility Network Facilities or "One Hole, One Management for Multi Functions" approach. The primary aim is to provide insightful recommendations and valuable perspectives on the effective and efficient management of utility networks in these designated areas. The ultimate objective is to improve the residents' quality of life and foster sustainable urban development. On the contrary, the establishment of an integrated utility network presents challenges due to its implementation in densely populated areas and busy road networks. Such circumstances are likely to result in significant disruptions and objections from the local community, primarily concerning traffic congestion and inconvenience (Munikoti et al., 2021; Kim et al., 2010;

Rahmat et al., 2021; Gámez et al., 2016). Therefore, it is crucial to adopt an appropriate working methodology to minimize disturbances and alleviate community concerns. This issue is of significant interest for conducting research aimed at designing models, methods, and cost estimation for constructing integrated utility network facilities in Denpasar City. Research purposes The aim of this research is to provide insights, recommendations, and guidelines for improving the utility supply model in Denpasar City, which ultimately improves the quality of life of its residents and promotes sustainable urban development.

IJPSE e-ISSN: 2550-6943 □ p-ISSN: 2550-6951 Sudiarsa, M., Sudiasa, I. W., Wibawa, I. G. S., & Sutapa, I. K. (2023). Analysis of the model of integrated utilities network provision and infrastructure in Denpasar City. 1 International Journal of Physical Sciences and Engineering, 7(2), 11–22. https://doi.org/10.53730/ijpse.v7n2.14452 13
Benefit of research Overall, this research can provide positive results such as increased efficiency, sustainability, service quality, and economic development, which are beneficial to residents and the development of Denpasar City as a whole.   2   Materials and Methods This research employed a descriptive method with quantitative data analysis. The research process comprised several stages, including a literature review and data collection from primary and secondary sources. Field surveys were conducted to gather information on the existing utility infrastructure, the number and issues of utilities, land use and urban spatial planning, road conditions, and the topography of the study area. Additionally, coordination and discussions were held with utility network managers in Denpasar, such as DPUPR 10 (Public Works and Spatial Planning Agency), PDAM (Water Supply Company) Denpasar City, Telkom (Telecommunications Company), and DSDP-BLU PAL (Waste Management Agency). Furthermore, a detailed analysis was conducted on the collected data, focusing on road inventory, construction techniques, methods, and associated costs.   3   Results and Discussions Overview of the Denpasar City utilities network The city of Denpasar is bisected by the Tukad Badung River, creating a

perceptible division within the city. The study area, chosen as a priority location for the development of integrated utility network facilities, is situated on both the western and eastern banks of the Tukad Badung River, as illustrated below.   Figure 1. Integrated utility grid plan In the city of Denpasar, the road space is extensively utilized for the installation of utility networks, including telephone networks, electricity networks, water pipe networks, wastewater networks (DSDP), and fiber optic networks. These installations are typically carried out on main roads, secondary arterial roads, and primary/secondary collector roads, leading to frequent excavation and backfilling activities. Such practices are observed almost every year. The findings of the utility network inventory in the study locations are presented in Table 1.

e-ISSN : 2550-6943 p-ISSN : 2550-6951 IJPSE   Vol. 7 No. 2, August 2023, pages: 11-22 14 Table 1 Existing road inventory results No Roads Long (m) Wide (m) Surface Type Type of Utilities Present 1. Imam Bonjol- Buagan St 2,960 10-25 Asphalt (AC, HRS, ATB) Power, Telkom cable, Optic Fiber, PDAM pipes (Ø4, Ø8, Ø14) 2. Thamrin. St 380 9 - 25 Asphalt (AC, HRS, ATB) Power, Telkom cable, Optic Fiber, PDAM pipes (Ø3, Ø8, Ø15) 3. Wahidin. St 230 9 - 25 Asphalt (AC, HRS, ATB) Power, Telkom cable, Optic Fiber, PDAM pipes (Ø6, Ø10) 4. Setiabudi. St 770 9 - 25 Asphalt (AC, HRS, ATB) Power, Telkom cable, Optic Fiber, PDAM pipes ((Ø4) 5. HOS. Cokroaminoto. St 980 9 - 25 Asphalt (AC, HRS, ATB) Power, Telkom cable, Optic Fiber, PDAM pipes ((Ø6) 6. Sutomo. St 940 9 - 25 Asphalt (AC, HRS, ATB) Power, Telkom cable, Optic Fiber, PDAM pipes (Ø6, Ø14) 7. Gajah Mada. St 730 10-25 Asphalt (AC, HRS, ATB) Power, Telkom cable, Optic Fiber, PDAM pipes (Ø3, Ø21) 8. Hasanudin. St. 758 10-25 Asphalt (AC, HRS, ATB) Power, Telkom cable, Optic Fiber, PDAM pipes (Ø2,Ø12,Ø15) Length of the west side of the Badung River 7.748   9. Kartini. St. 982,70 6,50 Asphalt (AC, HRS, ATB) Power, Telkom cable, Optic Fiber, PDAM pipes ((Ø12) 10. Sulawesi. St. 340 7,00 Asphalt (AC, HRS, ATB) Power, Telkom cable, Optic Fiber, PDAM pipes ((Ø4) 11. Ternate. St. 187 5,30 Asphalt (AC, HRS, ATB) Power, Telkom cable, Optic Fiber, PDAM pipes ((Ø4) 12.

Arjuna. St. 315 6,00 Asphalt (AC, HRS, ATB) Power, Telkom cable, Optic Fiber, PDAM pipes ((Ø6) 13. Sumatera. St. 335 9,00 Asphalt (AC, HRS, ATB) Power, Telkom cable, Optic Fiber, PDAM pipes ((Ø6) 14. Kalimantan. St. 128,50 6,50 Asphalt (AC, HRS, ATB) Power, Telkom cable, Optic Fiber, PDAM pipes ((Ø4) 15. Beliton. St. 210 9 - 15 Asphalt (AC, HRS, ATB) Power, Telkom cable, Optic Fiber, PDAM pipes ((Ø4) 16. Udayana. St. 250 10-25 Asphalt (AC, HRS, ATB) Power, Telkom cable, Optic Fiber, PDAM pipes ((Ø15) 17. Veteran. St. 754 9 - 25 Asphalt (AC, HRS, ATB) Power, Telkom cable, Optic Fiber, PDAM pipes ((Ø3) 18. Surapati. St. 390 10-25 Asphalt (AC, HRS, ATB) Power, Telkom cable, Optic Fiber, PDAM pipes ((Ø12) 19. Sugianyar. St. 158 9 - 15 Asphalt (AC, HRS, ATB) Power, Telkom cable, Optic Fiber, PDAM pipes ((Ø4) 20. Kapten Agung. St. 204 8,00 Asphalt (AC, HRS, ATB) Power, Telkom cable, Optic Fiber, PDAM pipes ((Ø6) 21. Kepundung. St. 792 8,00 Asphalt (AC, HRS, ATB) Power, Telkom cable, Optic Fiber, PDAM pipes ((Ø6) 22. Kaliasem. St. 184 11,00 Asphalt (AC, HRS, ATB) Power, Telkom cable, Optic Fiber, PDAM pipes ((Ø4) 23. Durian. St. 340 7,00 Asphalt (AC, HRS, ATB) Power, Telkom cable, Optic Fiber, PDAM pipes ((Ø3) 24. Diponegoro- Dewi Sartika 1.192 10-25 Asphalt (AC, HRS, ATB) Power, Telkom cable, Optic Fiber, PDAM pipes (Ø6, Ø12,Ø22) Length of the East side of the Badung River 7.491 Regarding the wastewater network at the study location, it is important to note that currently, it is only present on the east side of the Tukad Badung River. For analytical purposes, the study area will be divided into two sections: the west side and the east side of the Tukad Badung River. 2 The table below displays the respective managers of each utility network (Table 2). Table 2 Existing utility manager No Network Utilities Company 1 Electricity PT. PLN (Persero) 2 Clean Water Perumda Air Minum Tirta Sewakadarma 3 Telephone PT. Telkom 4 Fiber Optick PT. Telkomsel, PT Indosat, PT. XL 5 Urban Road City, Province and National 6 Water waste DSDP - BLU PAL Regarding the wastewater network in the study area, it is important to note that it is currently only present on the eastern side of the Tukad Badung River. To facilitate the analysis, the study area will be divided into two sections: the western side and the eastern side of the Tukad Badung River

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Analysis of integrated utility network model design The Integrated Utility Network Facility is a shared utility network that is installed underground, utilizing the road benefit area as a discreet location, and involving the private sector in its management (Laistner & Laistner, 2012). The design of the integrated underground utility network model places great emphasis on government initiatives, particularly sustainable development programs that promote environmentally sound and integrated solutions. In line with these objectives, the researchers have deliberately selected a box culvert-type precast concrete design for the underground infrastructure. Specifically, they have opted for rectangular-shaped precast reinforced concrete structures equipped with spigots and sockets. This choice of utilizing box culverts as utility ducting is anticipated to effectively mitigate unforeseen environmental challenges (Döner et al., 2010; Hwangbo et al., 2022; Hwangbo et al., 2017; Hwangbo et al., 2017). In addition to the previously mentioned factors, there are other reasons supporting the utilization of box culverts as a medium for integrating utility networks (Chu et al., 2021). These reasons are as follows: a) Versatility and Adaptability: Box culverts offer versatility in accommodating various utility services, including electrical cables, water pipelines, and gas lines. The design can be customized to suit specific requirements and can be easily modified or expanded as needed. This adaptability ensures that the integrated utility network can effectively cater to evolving demands and future infrastructure developments. b) Protection and Security: Box culverts provide excellent protection and security for the utility infrastructure. The reinforced concrete construction offers robust shielding against external elements, such as soil erosion, temperature fluctuations, and potential vandalism or tampering. This safeguarding aspect enhances the longevity and reliability of the integrated utility network. c) Maintenance and Accessibility: The design of box culverts allows for convenient access to the utility components for inspection, maintenance, and repair purposes. With easy entry points and spacious interior dimensions, technicians can carry out necessary tasks efficiently, reducing downtime and minimizing disruption to utility services. d) Environmental Considerations: Box culverts contribute to environmental preservation in several ways. Firstly, by consolidating utility infrastructure underground, it minimizes the need for surface-level installations, thus reducing land disturbance and preserving green spaces. Additionally, the use of precast concrete materials ensures sustainable construction practices by optimizing material usage and minimizing waste generation. e) Cost-effectiveness: Implementing box culverts as utility integration media can lead to cost savings in multiple aspects. The prefabricated nature of precast concrete components allows for streamlined manufacturing processes, reducing construction time and labor expenses. Moreover, the durability and longevity of box culverts contribute to long-term cost-effectiveness by minimizing maintenance and replacement costs. In designing the integrated utility network facilities and infrastructure in Denpasar City, the dimensions of the box culverts are carefully determined to accommodate the required number of network utilities, comply with relevant regulations regarding safe distances, and consider the existing road width conditions. The chosen design model utilizes a top-bottom type box culvert with specific dimensions of 140 cm in width, 180 cm in height, and 120 cm in length for each segment. This is illustrated in Figures 2 to 5 below.

  Figure 2. Utility ducting details west side   Figure 3. Utility ducting details east side   Figure 4. Utility ducting typical west side of Badung river

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17 Figure 5. Utility ducting typical east side of Badung river In Figures 2 and 4, the diagram illustrates that all network utilities are consolidated within a single box culvert. This design approach allows for the efficient integration and coordination of various utility services within one structure. However, in Figures 3 and 5, it is shown that the wastewater network has already been installed separately from the other utilities. Construction method analysis To support efficiency and effectiveness in construction, it is necessary to consider the construction method applied [6]. The other factors that influence the effectiveness of the implementation method are as follows: labor, equipment selection, material selection, traffic management, security for utilities, social and community, and environment. It is well known that the utility network work area is a densely populated area, densely populated with business premises and heavy traffic which has the potential to cause traffic disturbances, environmental disturbances (air pollution from dust, noise, traffic jams, residual engine exhaust gas/oil, water pollution from earth excavations). that enter water bodies, etc.) and raise objections from the community around the construction project, for this reason, an appropriate work method is needed so as to minimize the disturbance (Mavromatis & Kokossis, 1998; Shi et al., 2008; Newbery, 1997; Sărăcin, 2017). For this reason, the implementation of this integrated utility network applies the clean construction method, namely the principle of carrying out work in a clean, neat, and orderly manner so as to minimize disruption to community activities due to the construction of this utility network. The working principles of this method are: a) Not disturbing the security and safety of road users b) Do not damage city facilities and/or infrastructure by taking into account spatial and aesthetic aspects c) Earth excavation work and installation of Utility Boxes is carried out for each segment along 10 - 20 m d) The results of soil cleaning are transported directly to the temporary disposal site by means of transport such as a dump truck and the tub is covered with a tarpaulin so that dust does not generate in transit. e) Box culvert materials are not placed on roads or sidewalks except in the work area and stock files should be provided around them f) When there is no work activity, all equipment

is demobilized so that the road can be passed by vehicles again g) The work area is limited by a safety fence and is equipped with adequate traffic signs. If the work is carried out at night, adequate lighting and security must be prepared h) After the completion of work for each section, all holes used for excavation or demolition must be closed immediately or secured with safety fences (barricades). i) Every day douse with water around the workplace to avoid dust j) Working hours are adjusted to traffic conditions and the conditions of the people around the work area

e-ISSN : 2550-6943 □ p-ISSN : 2550-6951 IJPSE Vol. 7 No. 2, August 2023, pages: 11-22 18 k) If the work is done at night, then the planned working hours: preparatory work, mobilization 8 – 9 PM, asphalt cutting 9 – 10 PM, excavation, installation DUB 10 PM - 4 AM, asphalt 4 – 6 AM and cleaning and demobilization 6 – 7 AM. Figure 6. Workspace in the middle of the road (temporarily closed) for roads <7 m Figure 7. Workspace without passage >7 m The construction method used in earthworks 8 is Cut and Cover, namely construction carried out by cutting or excavation and after installation is completed, the construction is backfilled or covered (Grigg & Fontane, 2000). This method was chosen because this utility network is a shallow underground channel (close to the original ground level) and is usually box-shaped (Box Culvert) so it is not possible to use the Tnunnel Boring Machine method. While the steps for installing box culvets using the clean construction method are as follows: a) The installation work of the Box Culvert 1400/1800-Top bottom was carried out after the sandfill work was completed and used a Truck Crane with alternating and human power. b) For Box Culvert installation work because of its Top Bottom shape, the installation that is done first after the song is prepared is the Bottom part of the Gutter1400/1800. c) Alternating tied at two points on the side of the gutter, 2 can be seen in (Fig. 9) then the top of the gutter 1400/1800 will be installed, can be seen in (Fig. 10). d) Backfill work was immediately carried out after the Gutter installation was completed and the joint plate was installed. (Fig. 11).

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19 Figure 8. Lay Out the Box culvert installation Figure 9. Lower gutter installation work 1400/1800-1200 Figure 10. Lay Out the Box culvert installation Figure 11. Lay Out the Box culvert installation AspalAspal Gambar 5 .7. Pekerjaan Pemasangan Bottom Gutter 1400/1800-1200 Gambar 5 .8. Pekerjaan Pemasangan Top Gutter 1400/1800-1200 Barikade Seling Mobile Crane Bottom Gutter 1400/1800 Pasir Seling Mobile Crane Top Gutter 1400/1800- AspalAspal Gambar 5 .7. Pekerjaan Pemasangan Bottom Gutter 1400/1800-1200 Gambar 5 .8. Pekerjaan Pemasangan Top Gutter 1400/1800-1200 Barikade Seling Mobile Crane Bottom Gutter 1400/1800 Pasir Seling Mobile Crane Top Gutter 1400/1800- Barikade Bottom Gutter 140/180- Stamper Top Gutter 140/180 Pasir

e-ISSN : 2550-6943 □ p-ISSN : 2550-6951 IJPSE Vol. 7 No. 2, August 2023, pages: 11-22 20 Construction cost analysis In estimating the cost of construction of integrated utility network facilities and infrastructure (ducting utilities) in the City of Denpasar, the following methods are used: a) The parameter method, is a method that associates costs with certain physical characteristics of objects, for example: area, length, weight, volume, and so on. b) Using a list of price indexes and previous project information, namely by looking for comparison figures between prices at a certain time (a certain year) to prices at the time (a year) used as a basis. c) The unit price method, namely by estimating costs based on unit prices, is carried out when the figures indicating the total volume of work cannot be determined with certainty, but the cost per unit (per square meter, per cubic meter) can be calculated. Table 3 Construction cost estimation recapitulation No Description Total Price (IDR) 1 General 491,898,534.96 2 Drainage Work 3,164,278,456,80 3 Earthwork 67,117,909,87.04 4 Non-Asphalt Work

7,147,325,442.65 5 Asphalt Work 11,660,856,655.57 6 Structure and Utility Box 228,005,970,829.13 7 Pedestrian Arrangement Work 19.376.946.467,18 A Total Job Price 336,965,186,258.34 B PPn 11 % x A 37,066,170,488.42 C Total Cost (A + B) 374,031,356,000.00 From Table 3 above, the estimated cost of constructing integrated utility network facilities and infrastructure (utility ducting) in Denpasar City is 370,661,704,000.00. IDR with details of the route to the east of the Badung River 169,097,120,676.44. IDR and the west route to the Badung River 173,663,537,816.10. IDR 4 Conclusion Based on the results and discussion above, 2 it can be concluded that: a) Model of integrated utility network infrastructure and infrastructure in Denpasar City using precast Box culvert 1400 x 1800 x 1200 top-buttom type. b) The proper construction method for realizing the project is the clean construction method while for earthworks using 8 the Cut and Cover method, namely construction is carried out by digging and after completing the installation the construction is closed again. c) The estimated construction cost required for the provision of integrated utility network facilities and infrastructure (utility ducting) in Denpasar City is 374,031,356,00.00 IDR

Acknowledgments The author expresses his deepest gratitude to the leadership of the Bali State Polytechnic, especially P3M and the management of the Civil Engineering Department, who have supported this research from the start of its implementation to the realization of this report.

 Sudiarsa, M., Sudiasa, I. W., Wibawa, I. G. S., & Sutapa, I. K. (2023). Analysis of the model of integrated utilities network provision and infrastructure in Denpasar City. 1 International Journal of Physical Sciences and Engineering, 7(2), 11–22. https://doi.org/10.53730/ijpse.v7n2.14452 21

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