Advances in Engineering Research, volume 208
Proceedings of the International Conference on Innovation in Science and Technology (ICIST 2020)

Construction System of Building Block for the Child Pedestrian-Friendly Pathway Prototype

Febriane Paulina Makalew*, Steve Wilben Macquarie Supit, Novatus Senduk
dept. Civil Engineering
Manado State Polytechnic
Manado, Indonesia
*febriane.makalew@polimdo.ac.id, stevewmsupit@gmail.com, novatussend@yahoo.com

***Abstract*—The construction system chosen for a prototype is part of the implementation of concept design including a pedestrian pathway. With the main user, the pedestrian is children, the process approaches considering child characteristics. Two main areas for child pedestrian-friendly prototype are the pedestrian area and playing area. This research aims to evaluate the construction system of a child pedestrian-friendly prototype with a building block approach. Methods use is study field and computer laboratory design process using software Auto CAD. Existing pathway construction material, characteristic and design is evaluated. The result shows that construction system of building block approach should include the activity, dimension, design pattern, and module method with the paving block as the main material. The problems in building block construction join system and material chosen should be consider in related to aspect of safety. The prototype can be applied in areas with a large number of children pedestrians such as school and public areas. Research in the future should widely consider the environmental impact on the location for the pedestrian pathway with the varied design approach.**

Keywords—child pedestrian, construction material, prototype, process design, the building block

I. INTRODUCTION

The child pedestrian pathway prototype is studied in this paper. The concept of a child-friendly environment improves the quality of pedestrian facilities in potential pathway area. This research aims to evaluate the building blocks as a construction system for the prototype design. The method for collecting data is a survey on-site area and computer laboratory design process. The design process is created through a computer design program including Auto CAD. The design prototype is a pedestrian pathway and playing area for children. Results show that the building block system for child pedestrian pathway in the field area is need to be evaluated in designing a child pedestrian pathway prototype. The building block system is a modular system in which the material is fabricated and can be resembled on-site to suit the condition of the site field. The process of design a child pedestrian pathway is including establish patterns on the prototype, explore the possibility of movement based on children's needs, enrich the area with an attractive object, consider color used, evaluate safe material, and join system based on the building block approach. Problems in using material of paving blocks for pedestrian pathway are related to construction join and surface performance. Building block system support the time of installation on site to avoid the use of street as child pedestrian pathway. This is to support in providing safety area for children. Further study needs to conduct for the implementation of a construction system of building block based on pathway design and for a different area of the pathway in considering the surrounding environment.

II. LITERATURE REVIEW

The concept of the building block or modular system is a prefabricated system in which develop in modern building construction. The modular system is time-efficient in design and construction techniques as well as safety and friendly environment [1]. The use of modular construction is to measure factors including social factors such as safety and noise, environmental factors such as energy consumption, and economic factors such as time and budget of construction [2]. The modular system is better than the conventional system [2]. The comparison of the construction system of prefabricated and in situ concrete using a decision-making tool show the production method in the structure where the decision-making process is important in achieving the quality of productivity [3].

The arrangement for the concrete brick block aims to give an impact on shape, texture, color, durability, strength, and resistance to humid [4]. Moreover, patterns for concrete block need to consider aspects of aesthetics, ecology, and maintenance [4]. The ecology aspect is related to the absorption of water with sand as construction based [4]. The surface of material needs to have good quality for long term use, resistance for traffic flow, contrast color and texture, rough surface, strong joint with street material, and able to reduce the effect of glare [5]. The coefficient of the surface is more than 0.55 [5]. Performance on paving block with laying pattern of stretcher bond, herringbone 90o and herringbone 45o and joint width 3 mm, 5 mm and 7 mm show the best is 45o laying pattern and 3 mm joint width [6].

The concept of the construction system process for the prototype of the pedestrian pathway is considered the standard of pathway and criteria of a child-friendly environment. Accessibility and the comfortable area is important in providing pedestrian pathway [7,8]. Moreover, the material used for the construction system needs to consider pedestrian flow and activity. The previous study on pedestrian pathways shows the importance of available space for pedestrian activity include child movement and pattern [9-16]. Therefore, the applied research for the prototype of a child pedestrian pathway should be conduct to implement and test the theory to be used in daily activity. Process design needs to consider factors of material use, the joint system in pedestrian pathway area, joint system with street and surrounding environment, design, zoning area. The number of objects to play activities and environment elements most consider by engineering experts [17]. Object to play activities such as swing and environment elements such as benches [17].

III. Methodology

Methods used in this research is a combination of study field and computer laboratory design process using software Auto CAD. For study field, a number of areas with potential child pedestrian in urban and rural area in North Sulawesi province is observed and evaluated. For computer laboratory design, pedestrian pathway in the area selected have been drew and classified based on different types of pedestrian pathway and their construction system. This basic design supports the process of design the prototype of pathway.

IV. Results and Discussion

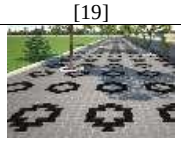
The construction system for the pedestrian pathway consists of different types of construction methods. Based on a literature study and recent research, the type of construction system including building block system or prefabricated system, conventional system or in-situ system, the combination of in-situ and prefabricated and lock block system. The comparison of the fabricated method and conventional method of concrete show the more effective and efficient system perform by fabricated. The use of form-work is the less on-site therefore friendly environment. The type of construction system can be seen in Table I.

TABLE I. Type of Construction System for Pedestrian Pathway

No	*Type*	*Example material*
1	Block system forbuilding the wall	 [18]
2	Conventional system or in-situ concrete Construction system for Material Concrete.	
3	Construction system Material Paving block	
4	Construction system Material Ceramic	
5	Construction system Material Pebble construction systems of prefabricated,	
6	the combination of the in-situ and prefabricated concrete construction system	

The development of construction system and material for pedestrian pathway is widely including environmentally friendly material. Using material paving block, the type of paving block for potential material is considered Eco-friendly material which can be seen in Table II.

TABLE II. TYPE OF PAVING BLOCK FOR PEDESTRIAN PATHWAY

No	*Type of Material for Pathway*	*Potential Material*
1	Interlocks brick	 [19]
2	Eco-lite interlock brick-block	 [19]
3	Aqua clay paver	 [20]

The characteristic of the construction system for a pedestrian pathway is important to recognize to provide a safe and comfortable facility for the user. The characteristic is including texture, color, joint, and durability that can be seen in Table III.

TABLE III. CHARACTERISTIC OF CONSTRUCTION SYSTEM FOR PEDESTRIAN PATHWAY

No	Characteristic	Source
1	long term use resistant to traffic flow rough surface a strong bond with street material reduce re-flexion	[5]
2	character of shape durability strength resistance to humid aesthetic ecology maintenance	[4]
3	Texture color	[4], [5]
4	Productive system prefabricated	[3]
5	laying pattern joint width	[6]

The pedestrian pathway in the study area of research is the facility with the majority child as the user. Based on different material use on the pathway, the evaluation considers the condition of material use, joint system, the object for playing available, design of surface, and zoning area. The detail of the evaluation can be seen in Table IV.

TABLE IV. EVALUATION PROCESS DESIGN OF PEDESTRIAN PATHWAY

No	Type of Pedestrian Pathway	Condition of Material Use	Joint System	Object	Design	Zoning Area
1	Pavingblock	Partly damage	Sand based	No object	Grey color	Walking area only
2	Concrete	Partly damage	Concretebased	No object	Grey color	Walking area only
3	Ceramics	Partly damage	Concretebased	No object	Orange color	Walking area only
4	Pebble and concrete	Partly damage	Concretebased	No object	Black and white	Walking area only
5	Ground soil and grass	Partly damage	Soil- based	No object	Black and green	Walking area only
6	Mix material	Partly damage	Concretebased	No object	Orange, black and white color	Walking area only

The use of paving blocks for pedestrian pathways can be seen in many parts of the street including the housing area where the local street functions as pedestrian pathways and public area. The area for evaluation of the construction system of the paving block can be seen in Fig. 1.

(a) (b) (c)

Fig. 1. Paving as material for the local street as a pedestrian pathway in the housing area in Manado (a), Pedestrian pathway in public main street (b) and Pathway only for pedestrian.

The evaluation of the pedestrian pathway with the paving block as a construction material is including the join system and the surface performance can be seen in Table V.

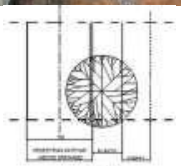
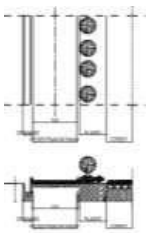
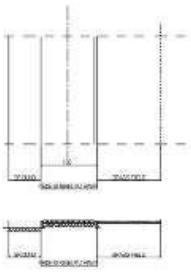
TABLE V. EVALUATION OF THE PAVING BLOCK CONSTRUCTION SYSTEM

No	Condition of paving block	Evaluation
1		Join of construction is damage due to wider distance between a piece ofpaving block
2		Other materials such as concrete blend with thepaving block need to beremoved
3		The edge of the paving block including join of different shape and function of the paving block such as pacing curb may lose the strength of join and damage the material
4		An even surface of pacing block may be due to the unstable base of the groundsurface
5		Damage of the edge of the piece of paving block
6		The join between paving block allow plants and moist to grow in which canreduce the strength of join construction
7		Join within different material such as ceramic with paving block can losestrength and damage the surface

The pedestrian pathway on the field study damage in terms of the construction join system and material use. Thereis a need to design and construct material for a pedestrian area. The construction on site will consume more time, therefore the area for child pedestrian will be detour to street area. As safety is more important for child pedestrian, the construction system need to be design into building block system to reduce installation time.

The design for child pedestrian-friendly is the potential tobe developed. Considering the existing condition of the pathway on the study area, characteristic for the pedestrian pathway, and the concept of the construction system, it is possible to create a prototype for the child pedestrian pathway. The potential child-friendly pathway can be seen inTable VI.

TABLE VI. TYPE DESIGN FOR THE CHILD PEDESTRIAN PATHWAY

No	Type of pathway	Potential Child-friendly pedestrian
1	Drainage under pathway: Urban Area near the school and public area. Drainage system under thepathway. Material ceramics with orange color, pebble white, and black. Drainagecontrol hole cover with grate. Plants and tree available   	Improve surface material Foundation with reinforced concrete Object provided Improve color scheme Available pattern based on the movement Available playingarea.
2	Drainage adjacent to the pathway 	Improve surface material Reinforced concrete construct above drainage system Object provided Improve color scheme Available pattern based on the movement Available playing area.
3	No drainage Rural school and park area Material paving block orange color. Children playground adjacent with sliding and swinger Soil - pathway-field with grass  	Improve surface material with paving block Foundation strong base Object provided Improve color scheme Available pattern based on the movement Available playing area

The design prototype is a pedestrian pathway and playing area for children. The building block system is used for design and construction the child pedestrian prototype can be modified to several alternative solutions. A building block system is a modular system in which the material is fabricated and can be ensembles on-site to suit the condition of the site field. Children as main user need a safety and comfort area of walking and playing. The modular system needs to accommodate the requirement for child-friendly pedestrian pathway. Moreover, the space for child activity should be appropriate. The size area of the prototype is included an area for walking as the art of the pedestrian pathway and an area for playing as wide as 12-meter square. This area is including pathway width of minimum 1.6 meter based on study of child movement [9,10].

The design for a prototype of a child pedestrian pathway is including establish patterns on the prototype, explore the possibility of movement based on children's needs, enrich the area with the attractive object, consider color used, evaluate safe material, and join system based on building block approach.

The pattern of the pedestrian pathway prototype is based on child activity including playing and walking. Playing requires area for playing according to child preference based on research such as an area for playing with the natural and mad-made object and running. The pattern on the walking area is based on child movement. The material provided is designed based on this pattern.

Children's movement along the pedestrian area is a straight pattern and zigzag pattern. Movement for playing area is free movement yet for a limited area the flow of children's movement as the pedestrian is continued such as straight movement following the shape of the square area.

An attractive object is an object used by children to play based on their preference. Children tend to play objects from nature such as leaves, branches, and stones.

Color use is defined as an attractive color. the color used is basic color including red, blue, and yellow. these colors create other colors such as green and orange. the bright color is attracted to users including children. natural color also uses as color from nature objects prefer by children such as green, white, and brown.

Fig. 2. Example of concrete block with color for pavement safe material.

The material used for the prototype is a set of safe materials considering children's activity. Children are active during their journey as pedestrians along the pathway due to their activity such as walking, running, and playing. This action needs a safe surface with less impact on slippery and falling.

The join system for the prototype material is to use a general system for paving block and other material chosen using sand and concrete. the system is easy to construct, the connection between paving and other concrete material uses a system of the puzzle for a strong connection.

The shape area for the prototype is a square area to fit the pedestrian area and easily arrange to the material join and surrounding area.

This prototype is the design and construction system for the pedestrian pathway in which the child is the main user. The prototype is included playing area as part of the pedestrian area and the material developed into attractive material in terms of texture and color. The prototype construction system isconsists of the material chosen, construction system, activity related to the design of the surface, and object available.

V. Conclusion

The prototype of the child-friendly pedestrian pathway is evaluated including the type of construction system, type of Eco-material of paving block, characteristic of the construction system. The evaluation of pedestrian pathways in the study area shows that there is a lack of maintenance of construction and availability of object areas for children to play. The construction system is including the material used, the color for an attractive pathway, and the design pattern. The construction system used for the prototype is a building block system with prefabricated and modular to adjust the paving block in the area of walking and playing.

Acknowledgment

This research is funded by the Center for Research and Community Service Unit Manado State Polytechnic under the scheme of Applied Research 2020.

References

[1] Generalova, Elena M., Generalova, Viktor P., Kuznetsova, Anna A. (2016), Modular buildings in modern construction, XXV Polish – Russian – Slovak Seminar “Theoretical Foundation of Civil Engineering” Procedia Engineering 153 (2016) 167 – 172

[2] Hammad, Ahmed WA., Akbarnezhad, Ali., Wu, Peng., Wang, Xiangyu dan Haddad, Assed (2016), Building information modeling-based framework to contrast conventional and modular construction methods though selected sustainability factors, Journal of Cleaner Production Volume 228, 10 August 2019, Pages 1264-1281

[3] Shahpari, Maryam., Saradj, Fatemeh Mehdizadeh., Pishvaee, Mir Saman and Piri, Saeid (2020), Assessing The Productivity Of Prefabricated And In-Situ Construction Systems Using Hybrid Multi- Criteria Decision Making Method Journal of Building Engineering Volume 27, January 2020, 100979

[4] Agah, Heddy R. and Lawalata, Greece Maria (2018), Pelaksanaan Permukaan Perkerasan Blok Beton Terkunci di Atas Lapis Pendukung Fleksibel Jurnal HPJI Vol. 4 No. 2 Juli 2018: 117-128

[5] Kementerian Pekerjaan Umum Dan Perumahan Rakyat (Kementerian PUPR), 2018, Pedoman Perencanaan teknis fasilitas pejalan kaki Bahan Konstruksi Bangunan dan Rekayasa Sipil Pd 03 - 2017 - B SE Menteri PUPR Nomor : 02/SE/M/2018

[6] Mudiyono, R., Nor, H.M., Hainin, M.R., Ling, T.-C. (2007) Performance of concrete paving blocks pavement on sloped road section. International Journal of Pavement; 6 (1-2-3): 136-145. http://trid.trb.org/view.aspx?id=88662

[7] Badan Standarisasi Nasional (BSN). 2004. SNI 03-1733-2004 Tata Cara Perencanaan Lingkungan Perumahan Di Perkotaan

[8] Badan Standarisasi Nasional (BSN). 1991. SNI 03-2443-1991 Trotoar

[9] Makalew, F P., Adisasmita S A., Wunas S., Hamid S, (2017) Influence of Children Pedestrian Behaviour on Pedestrian Space Usage, IOP Conf. Ser.: Mater. Sci. Eng. 2017, 271 012028

[10] Makalew, Febriane Paulina., Adisasmita, Sakti Adji., Wunas. Shirly and Aly, Sumarni Hamid.,(2018) Pedestrian Space Capacity and Movement Pattern for Elementary Students in Urban And Rural Area, International Journal of GEOMATE Vol.15 Issue 50, pp. 63 – 69

[11] Makalew, F.P (2019), Child Pedestrian Friendly Design Principle for the Settlement and Housing area, IOP Conference Series: Earth and Environmental Science 328 (1) (2019), 012018 Scopus

[12] Makalew, Febriane Paulina (2019) Studi Pilihan Moda Transportasi Anak Sekolah Dasar, Jurnal Teknik Sipil Terapan (JTST) 1 (01), 1-6 (2019)

[13] Makalew, Febriane P., dan Mandang, Deyke J,F (2019), Identifikasi Jalur Evakuasi Bencana Banjir Bagi Pejalan Kaki Di Desa Borgo, Prosiding Seminar Nasional Terapan Riset Inovatif (Sentrinov) ISSN: 2477-2097 Vol. 5 Tahun 2019

[14] Makalew, F,P., Supit, S W M , Kondoj, N E dan Mantiri, H G (2019), Planning Area of Resist Natural Disaster in Bentenan Village South Eastern Minahasa, 2nd International Conference on Applied Science and Technology ICAST, Bali Indonesia, Journal of Physics: Conference Series Journal of Physics: Conference Series 1450 012025 (2020) IOP Publishing doi:10.1088/1742-6596/1450/1/012025

[15] Makalew, F.P., dan Mandang, D. J. F (2020), Design principle of evacuation route for the pedestrian during a flood event in Borgo village’ IOP Conf. Series: Earth and Environmental Science IOP Conf. Series: Earth and Environmental Science IOP Publishing 419 (2020) 012091 Scopus doi:10.1088/1755-1315/419/1/012091 1

[16] Makalew, F.P., Adisasmita, S.A., Wunas, Shirly dan Aly, S.H (2020), Influence of elementary students walking speed to children pedestrian pathway planning. IOP Conf. Series: Earth and Environmental Science IOP Publishing 419 (2020) 012096 Scopus doi:10.1088/1755-1315/419/1/012096

[17] Atman, Cynthia J (2019), Design timelines: Concrete and Sticky Representations of Design Process Expertise, Design Studies Vol 65 No. C November 2019

[18] Mona Precast Ltd (2020) https://www.monaprecast.co.uk/

[19] Interlock Bricks (2020) https://www.indiamart.com/proddetail/interlock-bricks- 16668869648.html

[20] Wienerberger Ltd (2020), What is the purpose of a Sustainable Urban Drainage System? https://www.wienerberger.co.uk/tips-and-advice/paving/what-is-the-purpose-of-a-sustainable-urban-drainage-system.html