Development of Commercial Investment of Green Road Layup Geopory Production Machines Using FaBa Waste Material from Large Coal Heating Industries

Iwan Harianton[1][a], Agus Surjana Saefuddin[2][b], Heri Setiawan[3], Darman[4][c]
[1]*Study Program Manufacturing Engineering,* Polman Bandung, Jl. Kanayakan No. 21 Bandung – Indonesia 40135
[2]*Study Program Tool Making*, Polman Bandung, Jl. Kanayakan No. 21 Bandung – Indonesia 40135
[3,4] *Study Program TRM and Maintenance,* Polman Bandung, Jl. Kanayakan No. 21 Bandung – Indonesia 40135
Corresponding author: iwan_harianton@yahoo.com,

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Abstract: Indonesia is known to be the nation that puts investment priority on building infrastructure for the last six years. The most remarkable achievement was the national road and toll road construction that was in the year 2015-2016 the ministry of public work and housing had constructed 1,845 kilometers national roads excluding the toll road of about 1,000 kilometers connecting major cities in Java Island, the following year 2017 built 776 kilometers, 2018 built 766 kilometers and continue on by building toll roads and national roads including flyover bridges connecting cities in major islands of Indonesia of about 400 to 500 km each year. Such roads had been built to solve traffic problems which certainly lowering the stress of driving cars all around the city as well as driving intercity and interstate. This publication is to anticipate future road problems by allowing roads to certain extend will need to be enhanced due to its topological site or surrounding drainage failure by reconstructing the road under green road concept that can absorb rain water to be deposited in the soil for better soil fertility around road areas. Such concept had been realized by designing a prototype layup geopory machines specially designed to construct porous road that will eventually require by road management to avoid rain water trap that corrode asphalt from rain water inundated pond. The porous road is also categorized green road that help production of such road in new housing areas or areas that is built under environmental friendly concept. This paper is made available after completing two major research one was about geopory material that absorb water and two was about road production machine specifically build to layup mortar geopory material on the road. In addition, this idea was eventually realized from the teaching activities under Project Based Learning approach on the two credit units of Capita Selecta subject of Manufacturing System, Furthermore, commercial Investment will be discussed for further consideration as business person may interested in.

1 INTRODUCTION

Besides the demanded road construction from villages, districts, provinces, national roads and toll roads[a], they widens potential disaster around the nation as the statistic number count 2,342 disasters had been classified 92% from hydrometeorology disasters[b, c]. Therefore, more road construction will produce more potential disaster of hydrometeorology. Therefore, this research had been done to anticipate further solution in the near future. This research was made possible due to successful research on the

[a] https://www.thejakartapost.com/news/2019/11/05/govt-to-build-5000-km-of-toll-roads-national-roads-in-next-five-years.html.
[b] https://www.google.com/search?q=statistik+bencana+alam+banjir+di+indonesia&rlz=1C1CHBFidID918ID918&sxsrf/
[c] https://www.bps.go.id/indicator/168/954/1/banyaknya-desa-kelurahan-menurut-jenis-bencana-alam-dalam-tiga-tahun-terakhir.html.
[d] https://www.researchgate.net/figure/Coefficients-of-wear-and-friction-for-different-bearing-mechanisms_tbl1_243972353.

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geopory material and innovation on a special machine to layup geopory roads. The two previous research output were done on the study of new material for green concept that researchers promote.

1.1 Geopory material

The research on geopory material had been done in 2019 by allowing waste material known as FaBa from any large coal heating industries to be used for the binder of the newly design aggregate for porous road material production. Figure 1 below is the characteristic of the porous road material made out of stone aggregate bind by FaBa materials to form road hardened material namely mortar geopory.

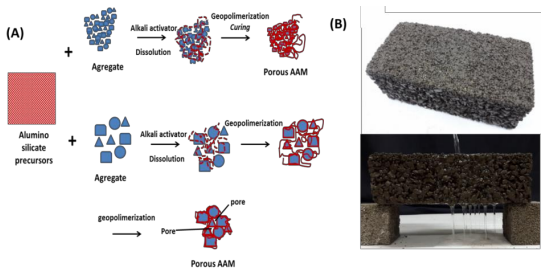


Figure 1. Mortar Geopolymer Structure

To be specific the geopory material in general consist of aggregate made out of construction stone screen for the size of 3 mm, 5 mm, and 7 mm. Those material bonded by FaBa and water of certain volume to form porous mortar geopory. Composition of those material and mixing compound will form mortar geopory of certain strength. The porous road after layup will be ready for use after 2-3 hours exposed to the dry environment, more humid areas will require longer draining period.

More wet or peat soil, mortar geopory road should be constructed differently as stability should remain assured for heavy road application. Figure 2 illustrates the recommended structure of geopory road for such soil condition.

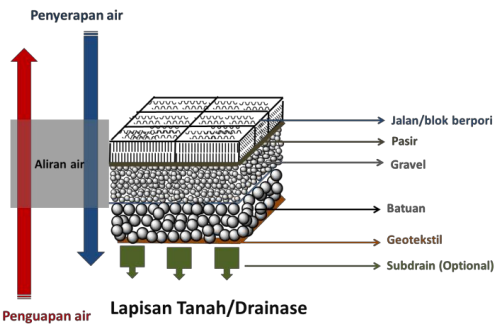


Figure 2. Mortar geopory road construction

There are six layer of the ideal mortar geopory construction, from the bottom layer the lowest element is optional namely the Pile, the second layer namely Geotextile made out of thin translucent material, the third layer will be Coarse split stone, the forth layer will be Gravel or Fine split stone, the fifth layer will be Sand, and the last layer will be minimum 10 cm made from mixing Mortar Geopory material. The above application that meet road construction quality standard subject to certain Intellectual Property Right agreement.

1.2 Special Machine Design

Production machine that layup geopory on the road surface is mainly a special vehicle that carry mortar geopory hopper size of 1,2 m^3 or 2.88 tons weight that can lay up material for the porous road production of 10 cm thick, 100 cm wide and 10 meter length after compaction by the attached roller weight of 2.6 tons. The mortar geopory is rather easy to harden due to FaBa binder mixed with porous hardener material. However, the surface will be ready for normal road application after 2-3 hours of drying in an open air.

Based on the total weight of vehicle, mortar and roller, this vehicle was constructed. The total force that should be overcome by engine power is due to mortar weight m_1, roller weight m_2 and the weight of the machine itself m_3 to run in certain acceleration which is designed to be 0.5 m/s2. Therefore the equation 1 is applied.

$$F = (\mu * g + a) * (m_1 + m_2 + m_3) \quad \ldots\ldots\ldots\ldots\ldots (1)$$

With the weight of the vehicle of 1.65 tons and μ=0.1 for friction of solid lubrication[d], then the force to move this type of vehicle should minimum be of 10.56 kN. Then with the diameter of the wheel of size 400/70/R20 will be calculated from the equation 2.

$$D = (400*70/2540)*2 + 20 \quad \ldots\ldots\ldots\ldots\ldots (2)$$

The Diameter for Torque calculation will be 42.0 inches or 1,068 mm. So for the four wheel drive vehicle the Torque requirement will be calculated from equation 3, while for the two wheel drive will be two time stronger (Senatore, C., 2010).

$$\tau = F/4 * D/2 \quad \ldots\ldots\ldots\ldots\ldots (3)$$

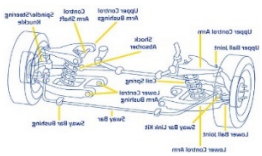
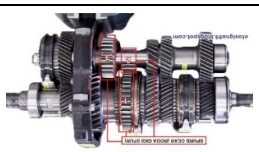
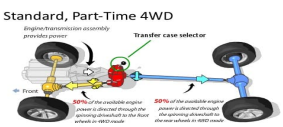
The Torque at least 1.32 kNm each wheel while the two wheel drive vehicle will require Torque of more than 2.64 kNm each, which was used to select the Torque of main engine (Harianton, et.al, 2022).

The design of the vehicle will include seven sub-assy that had been researched and prototyped through

several project based assignment directly supervised by the researcher. They are Electric Chassis, Engine Unit, Steering System, Suspension System, Gear Transmission, Drive System, and Body & Cockpit.

The design expectation was illustrated in table 1, where the ideal construction is described in the corresponding table. The final vehicle prototype had been constructed as described in section 1.3.

Table 1 Sub-assy Products

Sub-Assembly	Specification
	**Electric Chassis** - Multi segment Batterie 120A, 440 V, 60kWh. - Parallel integration - Mounted housing - Generator converter
	Range Extender 40HP: Stationary installed in the save garage for mobile charging in the field.
	Rack and Pinion steering system: - Mounted on chassis - Modular component for 4WD System
	Suspension system simplified without absorber for low speed vehicle replaced by synthetic rubber
	Gear reduction ratio 1:12 to produce large torsion and low speed vehicle.
	4WD system - Customized shaft and differential gear reducer - Cross joint to maintain bumpy soil as anticipated
	Cockpit is designed to suit man or un maned vehicle level 7 comfort - Option without monitor. - Monitor is provided for HMI and the supervisor monitoring and evaluation.

The engine has been picked from the previous research output specified as multi-fuel *REEV* Engine (Iman, et.al. 2022) installed to generate standalone electric charge to be carried with the vehicle for remote area road construction. The engine will charge Lithium ion electric car batterie pack 60kWh – 400V.

1.3 Mortar Geopory Vehicle Prototype

Vehicle prototype was done by student under close supervision from the researcher based on Modular Design Concept so that each sub-assy had been prepared by a group of students of 3 – 4 people that communicate effectively to define sub-assy interface joint in under plug and play installation concept. This vehicle is also subject to Intellectual Property Right Agreement for commercial application (Wong, J., 2010).

Figure 3 illustrates the final vehicle prototype which is carrying mortar geopory hopper size 1.2 m^3 ready mixed and also carrying compacted roller of 2.6 tons weight.

Figure 3. Layup Geopory Road Production

The modular plug and play design concept had been released for commercial evaluation as business partners may be interested in producing the vehicle for their business plan formulation. Figure 4 illustrates the exploded view of the vehicle by eliminating the batterie mounting and drive system detail for patent pending registration and authenticity of its original claims.

There are 11 modular sub-assy that form layup geopory vehicle including 1). Cockpit and hood, 2). Hopper mortar geopory, 3). Roller compaction, 4). Dynamo Electric Motor, 5). Steering System, 6). Four Wheel Driver, 7). Electric Safety Break System, 8). High Power Batterie, 9). Chassis, 10). Leaf Spring Suspension, 11). 400/70/R20 Wheel. Each sub-assy is connected to main chassis and plug to the corresponding functional sub-assy that form modular design vehicle assembly. The comfort and rigidity is tested and licenced by the civil work equipment office for land user application (O.L Kolekar and J. M. Potekar 2014).

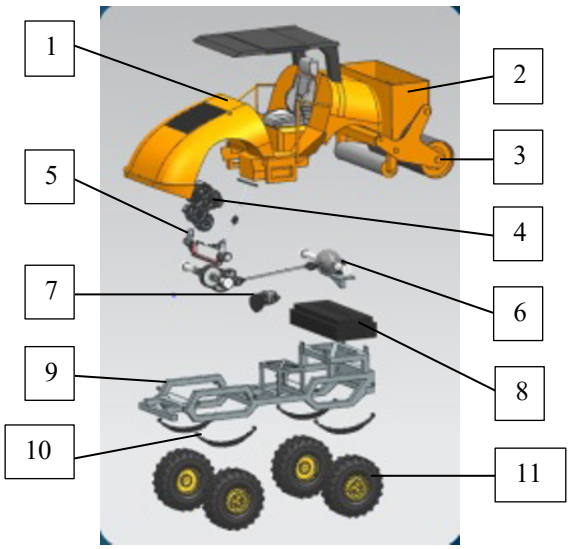


Figure 4. Exploded view of Layup Geopory Vehicle

The layup performance subject to Highrise setup for layup of hopper just 12-15 cm above the surface road. Application as the mortar should be laid up so the mortar geopory material exactly placed in the surface of the prepared road with the thickness of 12 cm before compacting the mortar immediately by the roller. The final thickness of the geopory material will be 10 cm thick of porous geopory layer of the green hardened road. The absorption capacity of the geopory layer of 1 m^2 surface will be guarantee to absorb 1 m^3 water per hour. Furthermore, Vehicle is also subject to one year operational guarantee maintenance based on performance, as suggested (Arief S. Gunawan, et.al. 2017).

2 COMMERCIAL INVESTMENT

The above two different research outputs offer three business schemes that Investor may be interested to invest in the market place. The market place is continuously increasing in Indonesia as the national economic development increase to optimize the exploration of minerals as well as to distribute products from fertile lands.

These research outputs will be immediately demanded as the problems of civil road construction developed nationwide. The functional road from rural to toll roads, and the ecological road that communities develop for green living areas. The estimated road all around the nation had reached 867,012 km long in 2020, that around 5% will require green road construction to avoid hydrometeorology disasters. So more than 43,000 km road should be constructed under green road concept, at least constructing the shoulder of 1 meter wide along those road kilometers that already functional today.

The design specification of the layup geopory vehicle can produce 100 meter long in one hour, so for one shift of eight hour work the machine can produce at least 800 meter long in a day. Therefore, one month this machine will produce 20,000 meter or 20 km long of porous road. Then this machine can produce approximately 240 km of green roads per year. For the technical and economic life time of the vehicle of two years, then 480 km can be finished by one vehicle. Then, the total need at least 90 – 100 vehicles of its kind will be required for 5% green road potential in this country. When we consider housing community, then another 100 vehicles could be sold to any medium and large size housing developers.

Then, what will be the magnet of such research output for business investment. There are at least three potential business options that investor may take opportunity from this publication. **One potential business** will be the production of the vehicle itself for any experience manufacturing companies. All geometrical definition, standard parts, mounting, and assembly will be provided by researcher as part of the investment advantage of licence agreement based on the intellectual property right release and royalty product sold, see section 2.1. **The second business option** will be to invest on this vehicle and rent it to any small to medium size construction companies. The costing and the investment opportunities can be observed in section 2.2. **The third business option** will be to take construction tender or sub-contract from the developer, again the costing studies had been done and competitive to the traditional asphalt road construction tender, see section 2.3 for detail.

2.1 Vehicle Production as a Business

While the need of this vehicle had been discussed above, which is around 200 vehicles in two years

period, it will require production company to fulfil the demand. Therefore, ideally production capacity should be designed to deliver 2 (two) vehicles in a week. However, since this product is new in the market, and require certain awareness of the green road concept, business plan was constructed only 2 to 3 vehicles a month. Marketing personals should be equipped with excellent knowledge of the products and also provided with attractive incentive and bonus for any sales completed.

To produce the vehicle, manufacturing companies may need to invest on special tools, jig and fixture and also other power tools to assemble the vehicle, it may need some investment allowed up to IDR 1,200,000,000,-. Even though electric engine vehicle requires only fewer components compared to the internal combustion engine vehicle, it still needs spaces to make assembly process as comfort as possibly can. The fabrication of the vehicle including standard components such as lithium batterie and dynamo Electric Motor and assembled all together with the calculated cost of Production Process of IDR 628,703,500,- The sales projection for the first 3 (three) months is 2 vehicles per month, while the next 9 (nine) months will be projected 3 (three) vehicles. Table 2 illustrates the part of the cash flow chart for production business plan of one year analysis.

Table 2. First Month Production Business Plan

BUSINESS PLAN		**1st Month**
	Sales	2
Income		2.000.000.000
Sales Price	1.000.000.000	
Expenses		1.903.147.700
Production Cost	628.703.500	1.257.407.000
Marketing	100.000.000	100.000.000
Royalty	10%	125.740.700
Office Equipment		150.000.000
Overhead		50.000.000
Added Value Tax	11%	220.000.000
Profit/Loss		96.852.300
Present Value	(1.200.000.000)	95.893.366
Net Present Value	2.986.288.423	
IRR	22,4%	
Payback		95.893.366

The sale price is projected IDR 1,000,000,000.- while the cost of Marketing is allocated of IDR 100,000,000.- per month, Royalty product of 10% of the production cost, Office Equipment only for the first set up of IDR 150,000,000.-, Overhead IDR 50,000,000.- per month, and Added Value Tax of 11% or equivalent of IDR 220,000,000.- per month or more. Based on the business plan projection above analysed for 12 month period and by considering cost of money decline of 1% per month. Then the business indicator had book the profit margin in the first month of about IDR96,852,300.-, when the sales volume is achieved for the next 12 months, then this business could perform Net Present Value of IDR 2,986,288,423.- which is very impressive, with Internal Rate of Return reach 22,4% and payback can be achieved in the fifth month of the business.

2.2 Invest One Machine to be Rented

The second business option is to invest one machine to be rented to small and medium size companies. The investment value is IDR 1,000,000,000.- to be rented with standard rented value of IDR 200,000.- for layup geopory for 1 m^3, while the capacity of the vehicle can lay up 2,000 m^3 mortar geopory per month. The cost is all inclusive to layup 2,000 m^3 mortar geopory in one month including cost of operator, fuel, marketing, maintenance and tax. The operational cost per month will be IDR 254,000,000.- net. Table 3 illustrates the first month business plan chart of the one year Cash Flow analysis.

Table 3. First Month Business Plan Vehicle Rented

Cost of Money reduction of 1%		**1st Month**
Sales	Layup (m^3)	2.000
Income	200.000	400.000.000
Expenses		254.000.000
Marketing		20.000.000
Fuel and Main,	25.000	50.000.000
Operators	50.000	100.000.000
OH+Depreciation	10%	40.000.000
Tax	11%	44.000.000
Profit/Loss		146.000.000
Present Value	(1.000.000.000)	144.554.455
NetPresent Value	643.241.311	
IRR	8,8%	
Payback		144.554.455

The cost of Marketing is allocated of IDR 20,000,000.- per month, Fuel and Maintenance IDR 50,000,000.-, Operators are allocated IDR 100,000,000.-, Overhead+Depreciation is allocated of IDR 40,000,000.- per month, and Added Value Tax of 11% or equivalent of IDR 44,000,000.- per month. Based on the business plan projection above analysed for 12 month period and by considering cost of money decline of 1% per month. Then, the business indicator had book the profit margin in the first month of about IDR146,000,000.-, when the

sales volume is achieved for the next 12 months, then this business could perform Net Present Value of IDR 643,241,311.- which is very impressive, with Internal Rate of Return reach 8,8% and payback could be achieved in the eight month of the business. Interestingly, side business of many investors fall on this option because their money work for them.

2.3 Handling Green Road Production

Small and Medium size companies may take sub-contract job for building green road production. This business option may need to invest on Mollen and Mortar Hopper to feed Layup vehicle. The investment cost is allocated for mixing mortar and feeding mortar to vehicle around IDR350,000,000.-. The sale price of IDR1,150,000.- per m^3 geopory material. In one month, the machine could layup of about 2,000 m^3 material. So the income will be projected of IDR2,300,000,000.- per month. The cost of operation will be to rent layup geopory vehicle including operator, rent a feeder truck, preparing Mortar Aggregate and mixing the aggregate with the FaBa material. Tax will be paid for 11% from the sales income of IDR 253,000,000.- per month. Table 4 illustrates the first month business plan chart of the one year Cash Flow analysis of handling green road production.

Table 4. First Month Business Plan Road Production

Cost of Money	1%	1
	Layup (m^3)	2.000
Income	1.150.000	2.300.000.000
Expenses		2.178.000.000
Rent Vehicle	200.000	400.000.000
Operators	50.000	100.000.000
Rent Mobile Feeder	25.000.000	25.000.000
Mortar Aggregate	650.000	1.300.000.000
FaBa Material	50.000	100.000.000
Tax	11%	253.000.000
Profit/Loss		122.000.000
Present Value	(350.000.000)	120.792.079
NetPresent Value	1.023.119.452	
IRR	32,5%	
Payback		120.792.079

Based on the business plan projection above analysed for 12 month period and by considering cost of money decline of 1% per month. Then the business indicator had book the profit margin in the first month of about IDR122,000,000.-, when the sales volume is achieved for the next 12 months, then this business could perform Net Present Value of IDR 1,023,119,452.- which is very impressive, with Internal Rate of Return reach 32,5% and payback could be achieved in the third month of the business.

3 COPYRIGHT FORM

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4 CONCLUSIONS

This paper publishes normative research output of two substantial findings of green road material and the innovative vehicle design and production to produce alternative functional green road. The Technological Readiness Level had reached 8 scale, only less than 7% of minor modification for industrial application, including the maintenance approval and manual for one year operational guarantee. Furthermore, these findings had been completed with the study on the commercial investment of three business options. The options are very attractive as those three business offer positive cash flow. **The first business option** on Producing Layup Geopory Vehicle of 33 unit in 12 months, the business could perform Net Present Value of IDR 2,986,288,423.- and the Internal Rate of Return of 22,4% and payback can be achieved in the fifth month. **The second business option** on investing one Vehicle for rent is also interesting because such business option could generate positive business indicators including Profit margin in the first month of about IDR146,000,000.- when the sales volume is achieved for the next 12 months, then this business could perform Net Present Value of IDR 643,241,311.- which is very impressive, with Internal Rate of Return of 8,8% and payback could be achieved in the eight month. **The third business option** was to handle road construction job that book the profit margin in the first month of about IDR122,000,000.-, when the sales volume is achieved for the next 12 months, then this business could perform Net Present Value of IDR 1,023,119,452.- which is very impressive, with Internal Rate of Return reach 32,5% and payback could be achieved in the third month.

The only uncomplete work is to push the market on green road production, while no regulation yet to encourage road builder to construct porous road at least 5% of the whole road production. Certainly, the marketing push of these businesses are winning through price per m^2 differentiation as porous road only 10% higher than the traditional asphalt road, while porous road win 100% on the environmental campaign for any road production.

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Certainly, for my professional evidence, this publication had been backup by professional costing detail and can be readily withdrawn with the intention to take benefit from the intention for business implementation. Any business interest can contact us through the email message stated in the corresponding author on the heading, soon we will response you appropriately.

This vehicle production had been proven to be one of the learning media under the Project based Learning for Diploma III and Diploma IV in Manufacturing Technology. Furthermore, once the line business established, many new entrepreneur from the civil study program can benefit directly from it after they are graduated. Investors are also guaranteed to have his/her money work for them, once the awareness campaign has reached the mature level, which is predicted on the next few years to come.

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