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RESEARCH ARTICLE OPEN ACCESS

Test of Microstructur Permeable Asphalt Pavement Used Domato Stone (Quarsite Dolomite) As Course Agregate for Surface Layer of Road Pavement

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Abstract
The experiment works was dividing into two phases, for phase one was developed to investigate the properties of aggregates and straight asphalt qualities. The experiment work for phase two was developed to design the porous asphalt mix. In this phase Japan's method and Binamarga's method was used to define optimum asphalt content. In this phase, has result cantabro loss weight 77.10 for asphalt quality 3% and loss weight 9.70 for asphalt quality 5%. asphalt flow down, air void and density values. The experiment work for phase two was developed to investigate the qualities of porous asphalt. In this phase, wheel tracking machine test was used to investigate the dynamic stability of mixes.

Result of this research will be valuable for development porous asphalt technology. Based on the Scanning Electron Microscope (SEM) can be seen the microstructure and content of chemical elements present in the porous asphalt. : Oxygen 58.46%, Silicon 2.60%, Aluminium 2.91%, Sodium 5.75%, Calcium 19.11%, Sulfur 7.83%, Magnesium 3.52%, SiO_2 6.73%, Al_2O_3 6.40%, Na_2O 7.45%, CaO 46.25%, SO_3 27.05%, MgO 6.12%. Binamarga : Oxygen 61.82%, Silicon 13.58%, Aluminium 7.27%, Sodium 4.42%, Magnesium 1.65%, Sulfur 4.56%, Calcium 3.96%, Potassium 1.31%, Iron 1.26%, Titanium 0.18%, SiO_2 38.09%, Al_2O_3 17.29%, Na_2O 6.39%, MgO 3.10%, SO_3 17.03%, CaO 10.36%, K_2O 2.88%, FeO 4.22%, TiO_2 0.66%. Japan : Oxygen 58.53%, Silicon 8.41%, Aluminium 6.73%, Sodium 7.21%, Magnesium 4.39%, Potassium 0.86%, Calcium 9.21%, Sulfur 4.66%, SiO_2 23.18%, Al_2O_3 15.74%, Na_2O10.25%, MgO 8.12%, K_2O 6.39%, CaO 23.71%, SO_3 17.14%. Porositas : Japan : SEM HV 10.0 kV, View field 57.5 µm, SEM MAG 2.21 kx, WD 11.58mm, Det : SE, Date (m/d/y) : 06/20/13, Binamarga : SEM HV 10.0 kV, View field 31.1 µm, SEM MAG 4.08 kx, WD 10.63 mm, Det : SE, Date (m/d/y) : 06/20/13, Japan : SEM HV 10.0 kV, View field 28.8 µm, SEM MAG 4.04 kx, WD 12.00 mm, Det : SE, Date (m/d/y) : 06/20/13.

Key Words: Domato stone, Two Criteria Mixure, Peak Load and Stress, X- RD and SEM

I. INTRODUCTION

Permeable asphalt pavement or porus friction course is commonly knews as porous asphalt. The porous pavement is commonly used in Europe and Japan. The pavement cousist in a porous overlay and then to drain on he edges to the pavement (*Michael. E Barret. Ph.D*). The lot deposit of Domato stone in Indonesia was still not be exploited better. Among the exiting utilization of it most of it was exploited for traditional needs fireplace material, some last rasearch in the field of road construction showed that Domato stone was powerfull enough when mixtured material for pavemen stabilization. Domato stone is local material from sea location in the island of banggai half Sulawesi Indonesia. Its was kwarsit Dolomitan material Celebes (*Car Donald*, 1985). As course agregate on the surface layer Road Pavement.Capasity drain porous Asphalt were connecting correlasion with spacing hight and small porousity in structure Asphalt. Stability and Durability and Hydrolic conductivity its must be hight test than 20% (*Ruz. et. al*, 1990).Asphalt porous is open graded course Aggregate. Porousity asphalt porous (10%-15%) the structure made drain for flow water (*Nur Ali, et al.* 2005).

Aggregate was specimen mineral who was done for mixture road konstruktion in the asphalt pavement it's mush be 90%-95% for the total weight strukture or 77%-85% for all volume (*Alkin, et. al* 1997).

The term "quality related" indicates that the properties used in the mix selection and design process are those which determine it's on road performance. Thus if good test result for a mix are obtained in the laboratory there is confidence that the material will perform satisfactorily on the road. For this reason, standard of porous asphalt mixture in japan required the dynamic stability value reach 3000 pass/mm or more (Nakanishi, 2002)

The problems that the present porous asphalt pavements hold are a problem that a drainage function falls, the aggregates scattering loss and plastic deformation. Permeability to water is one of the characteristic properties of porous asphalt, i.e. drainage function. The drainage falls caused by clogging, where the voids of a mixture blockade with dust or movement of asphalt mortar (Nakanishi, 1995). Scattering of aggregates caused by ravelling. Plastic deformation related with rutting, caused of the porous asphalt pavements employ around more than 20 percent of air voids.

In laboratory, to know the quality related properties usually was tested with water permeability test, cantabro loss test, loss of running off test (drain down test) and wheel tracking machine test. Nakanishi, et al. (1996) also stated that cantabro loss and dynamic stability have relationship with percentage of air void and asphalt viscosity.
aggregate, i.e. 80%, 85%, and 90 %, also some provisional asphalt content combinations.

II. RESEARCH METHOD

The experiment works was divided into 2 (two) phases, for first phase was developed to investigate the properties of aggregates and asphalt qualities. The experiment work for second phase was developed to design the porous asphalt mix. In this phase Japan's method and Japan's method was used to define optimum asphalt content. In this phase, has result cantabro-loss, asphalt flow down, air void and density values. The experiment work for the last phase was developed to investigate the qualities of porous asphalt at optimum asphalt contents. In this phase, wheel tracking machine test was used to investigate the dynamic stability of mixes.

Tabel . 1. Recapitulation Gradation Model

ASPAL	GRADASI / KOMPOSISI AGREGAT	ASPHALT VALUE (%)	SAND VALUE (%)	No. Sampel	TEST: PERMEABILITAS* MARSHALL	PERMEABILITAS* CANTABRO	PERMEABILITAS* IKS	PERMEABILITAS* AVERAGE	POROSITAS* MARSHALL	POROSITAS* CANTABRO	POROSITAS* IKS	POROSITAS* AVERAGE	MARSHALL STABILITAS	MARSHALL FLOW	CANTABRO (%)	IKS STABILITAS	IKS FLOW	BINDER DRAIN-DOWN (%)
	JAPAN (3/8", 4, 8, 30, 50, 100, 200, PAN)	4,5		I	0,19	0,16	0,15	0,16	18,38	18,87	17,55	18,31	864,21	3,11	76,26	402,70	3,55	0,01
				II	0,18	0,15	0,14		17,45	18,63	17,94		844,93	3,35	79,67	411,50	3,20	0,02
				III	0,19	0,15	0,14		18,55	18,55	18,91		894,84	3,26	39,08	395,00	3,30	0,02
		5,0		I	0,11	0,11	0,10	0,11	16,66	17,94	17,08	17,00	1001,19	3,50	62,96	494,35	3,60	0,02
				II	0,11	0,12	0,12		16,96	16,46	16,03		942,23	3,80	55,81	452,30	3,85	0,05
				III	0,10	0,11	0,11		17,40	17,82	16,62		953,35	3,30	55,19	476,40	4,00	0,03
		5,5		I	0,09	0,08	0,09	0,09	15,43	15,86	15,51	15,71	1050,95	3,50	36,41	608,68	4,10	0,10
				II	0,09	0,09	0,10		15,47	16,25	15,08		1067,46	4,20	31,85	585,70	3,85	0,06
				III	0,11	0,08	0,08		15,75	15,16	16,67		1107,07	4,00	33,82	593,40	4,30	0,05
		6,0		I	0,08	0,07	0,07	0,07	14,59	14,90	14,94	14,41	1239,06	4,00	14,42	756,29	4,85	0,08
				II	0,07	0,07	0,07		14,41	13,26	14,01		1188,51	4,20	13,30	710,10	4,60	0,09
				III	0,07	0,08	0,07		14,77	14,30	14,50		1247,99	4,30	14,58	725,50	4,70	0,06
		6,5		I	0,07	0,06	0,06	0,06	12,65	12,70	12,65	12,59	1524,39	4,20	7,41	766,68	5,20	0,10
				II	0,06	0,07	0,07		13,65	12,35	12,30		1494,18	4,60	9,17	754,90	5,70	0,11
				III	0,07	0,06	0,06		12,49	13,54	11,02		1554,87	4,11	9,52	720,55	5,50	0,07
	BINA MARGA (1/2", 3/8", 4, 200, PAN)	4,5		I	0,22	0,27	0,25	0,26	24,30	24,44	22,49	23,54	616,00	3,30	75,00	191,33	3,80	0,03
				II	0,32	0,21	0,29		23,61	23,02	23,37		627,04	3,50	72,35	185,00	3,50	0,04
				III	0,25	0,24	0,25		24,12	23,00	23,36		619,99	3,80	74,30	165,40	3,30	0,03
		5,0		I	0,25	0,21	0,20	0,21	22,98	22,96	21,42	22,48	681,21	3,50	61,68	261,30	3,80	0,07
				II	0,22	0,20	0,19		23,61	22,96	21,47		690,31	3,80	63,08	220,60	4,10	0,06
				III	0,21	0,21	0,21		23,20	22,58	21,10		672,09	3,50	58,31	275,10	3,90	0,07
		5,5		I	0,15	0,18	0,17	0,16	21,44	19,49	19,14	20,00	829,98	4,00	55,14	351,82	4,30	0,11
				II	0,18	0,15	0,19		20,53	20,53	19,16		785,53	3,80	54,04	384,22	4,10	0,13
				III	0,16	0,16	0,14		20,86	19,49	19,36		824,34	3,90	55,42	360,10	4,70	0,11
		6,0		I	0,13	0,12	0,11	0,12	17,50	16,70	17,05	17,45	915,55	4,30	35,48	582,15	5,30	0,19
				II	0,12	0,12	0,12		17,52	17,11	17,76		880,57	4,20	33,27	540,10	5,00	0,20
				III	0,14	0,11	0,13		17,90	17,74	17,80		873,73	3,80	30,00	577,00	5,50	0,21
		6,5		I	0,11	0,10	0,09	0,10	16,71	15,14	16,68	16,55	1112,50	4,75	14,29	706,57	5,50	0,26
				II	0,10	0,11	0,10		16,65	16,65	16,58		1080,56	4,80	9,72	685,30	5,70	0,28
				III	0,10	0,10	0,09		17,85	16,38	16,33		1076,30	4,20	14,38	720,80	5,60	0,25

DATA AND ANALYSIS

Table 3. Shows properties of straight asphalt were used in the experiment. It shows that type of asphalt is straight asphalt BNA Blank penetration 60/70. In general, asphalt binder qualities comply with the requirement and recommended to apply for practical purpose.

Table 2. Properties of Aggregate

Properties asphalt	Value
Penetration (1/10 mm) 25^{o}C	64
Softening Point (^{o}C)	55
Ductility (cm)	> 140
Specific Gravity (gr/cm^3)	1,034

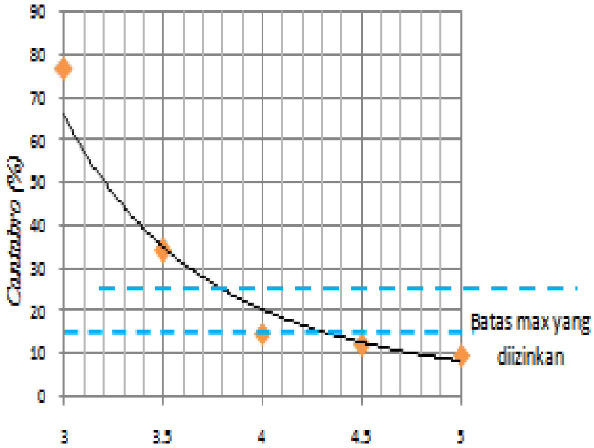
Table 2. Shows properties of aggregates were used to the experiment. It shows that material comply with the request in specification and recommended to apply for practical purpose too.

Table 3. Properties of Aggregates

Properties	Value
Coarse Aggregate	
Bulk Specific Gravity (gr/cm^3)	2,72
Saturated Specific Gravity (gr/cm^3)	2,67
Apparent Specific Gravity (gr/cm^3)	2,82
Absorption (%)	0,82 %
LA Test (%)	14,4 %
Fine Aggregate	
Bulk Specific Gravity (gr/cm^3)	2,68
Saturated Specific Gravity (gr/cm^3)	2,65
Apparent Specific Gravity (gr/cm^3)	2,68
Absorption (%)	1,28

Figure 1. Shows relation between cantabro loss and asphalt content. It illustrates that increasing in asphalt content, make decreasing in cantabro loss. It also shows that cantabro loss from Japan's method rank between cantabro loss Japan's method 85% coarse aggregate content and 90% coarse aggregate content. It explains that Japan's method content more than 85 % of coarse aggregate content.

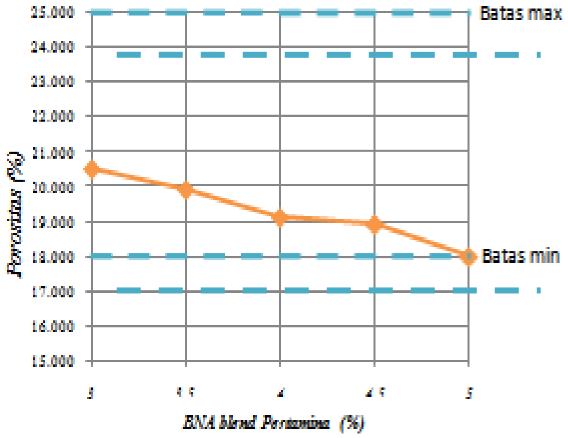
By adding asphalt content, it will increase aggregate surface area covered by asphalt film. This condition strengthening binding force between aggregates, therefore Cantabro loss value decrease. Cantabro loss value also affected by percentage of coarse aggregate. Higher the percentage higher cantabro loss value. Explanation of this condition is by increasing in percentage of coarse aggregate have an effect on decreasing in interlocking between aggregates.



Gambar 4.1 Corelation *BNA* with Cantabro

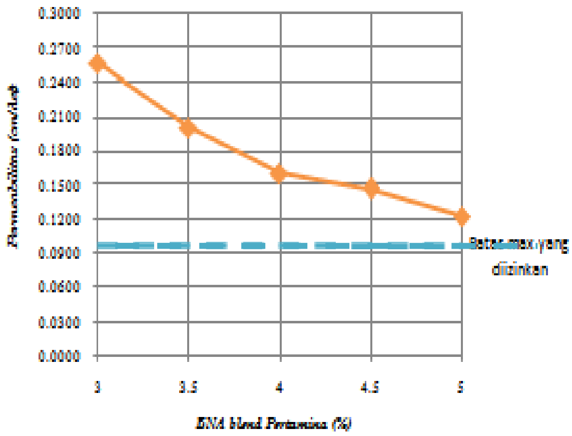
Figure 2. Shows relation between air void and asphalt content. It shows that increasing in asphalt content, make decreasing in air void. By adding asphalt content have an effect to the volume of void space was filled with asphalt binder. Higher volume of void was filled with asphalt binder, lower percentage of air void content.

It also shows that air void from Japan's method higher than air void Japan's method 85% coarse aggregate content. It can explain that higher coarse aggregate content have an effect to volume of void space in compacted asphalt mixes. Surface contact area of aggregates affected by their size. Bigger number size of aggregate will make surface contact area of aggregates lowest and it causes bigger in volume of void space. Furthermore, increasing in air void make decreasing in deformation resistance.



Gambar 4.2 Corelation BNA with porositas

Figure 3. Shows relation between loss of running off versus asphalt content. It illustrates that increasing in asphalt content, make increasing in loss of running off. This condition explains that melting possibility of asphalt binder will increase as increasing in temperature and asphalt-binder content. It also shows that loss of running off Japan's method most lowly.



Gambar 4.3 Corelation BNA with permeabilitas

From the two figures above, then used to define porous asphalt mix design. Table 5. Shows the result of mix design using Bina Marga and Japan's method, also dynamic stability was resulted from wheel tracking machine test.

III. Analysis Test of Loads and Stress

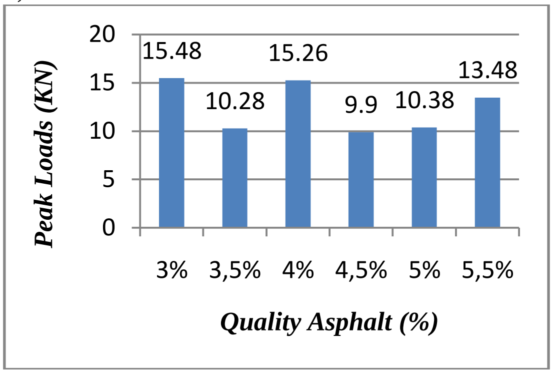
Figure 2. Tist Loads and Stress Asphalt by UTM Machine

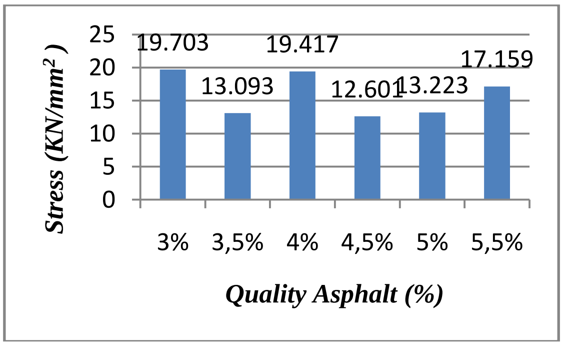
Table 5. Model Peak Load and Stress

Pressure Test				
QUALITY ASPHALT	WEIGHT (KG)	HEIGHT (cm)	PEAK LOAD (KN)	STRESS (N/mm2)
3%	1.680	11,1	15,48	19.703
3,5%	1.620	11	10,28	13.093
4%	1.670	10,8	15,26	19.417
4,5%	1.670	11,2	9,90	12.601
5%	1.665	10,6	10,38	13.223
5,5%	1.740	10,8	13,48	17.159

For quality asphalt 3% weight 1.680kg, height 11,1cm we get peak load 15,48 KN Stress 19.703 N/mm^2. For quality asphalt 3,5% weight 1.620 kg, height 11cm we get peak load 10,28 KN Stress

13.093 N/mm^2. For quality asphalt 4% weight 1.670 kg, height 10,8 cm we get peak load 15,26 KN Stress 19.417 N/mm^2. For quality asphalt 4,5% weight 1.670 kg, height 11,2 cm we get peak load 9,90 KN Stress 12.601 N/mm^2. For quality asphalt 5% weight 1.665 kg, height 10,6 cm we get peak load 10,38 KN Stress 13.223 N/mm^2. For quality asphalt 5,5% weight 1.740 kg, height 10,8 cm we get peak load 13,48 KN Stress 17.159 N/mm^2.





IV. Analysis X-Ray - Tomography

The results of research indicates that porous asphalt mixture showed an influence on the value of the characteristics of porous asphalt particularly at concrete grading 50% retained 1/2" and 50% natural crushed stone retained 3/8" where the values obtained from the analysis of optimum binder content is 9.5%. Based on the Scanning Electron Microscope (SEM) can be seen the microstructure and content of chemical elements present in the porous asphalt which prove that all elements of the BNA Blend Pertamina and concrete waste can blend and bind well.

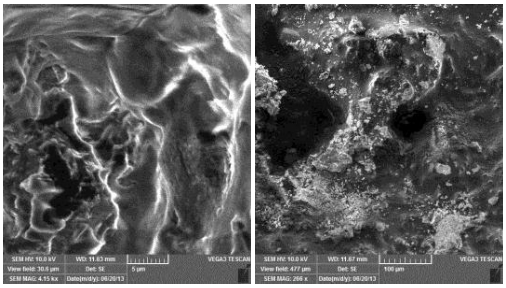


Figure 2. Photo X-Ray Permeable Asphalt (Japan Model)

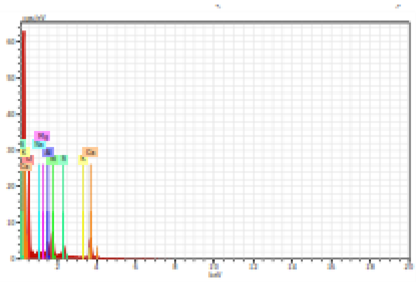


Figure 3. Tescan vega3SB

Spectrum: test

Element	unn. C [wt.%]	norm. C [wt.%]	Atom. C [at.%]	Compound	norm. Comp. C [wt.%]	Error (3 Sigma) [wt.%]
Oxygen	20.01	40.36	58.46		0.00	9.11
Silicon	1.56	3.15	2.60	SiO2	6.73	0.36
Aluminium	1.68	3.39	2.91	Al2O3	6.40	0.42
Sodium	2.74	5.52	5.57	Na2O	7.45	0.79
Calcium	16.39	33.05	19.11	CaO	46.25	1.68
Sulfur	5.37	10.83	7.83	SO3	27.05	0.76
Magnesium	1.83	3.69	3.52	MgO	6.12	0.50
Total:	49.57	100.00	100.00			

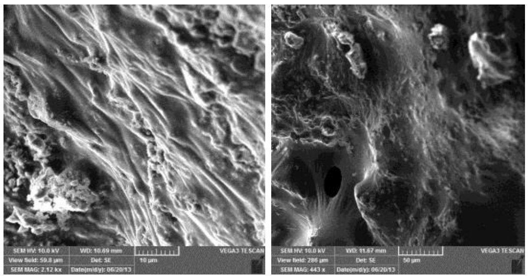


Figure 6. Photo X-Ray Permeable Asphalt Pavement (Binamarga Model)

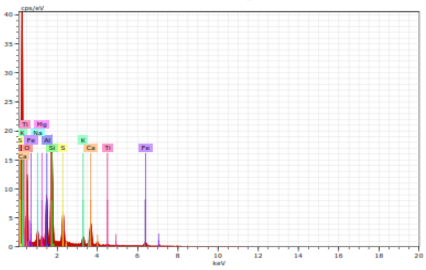


Figure 7. Tescan vega3SB

Spectrum: test

Element	unn. C [wt.%]	norm. C [wt.%]	Atom. C [at.%]	Compound	norm. Comp. C [wt.%]	Error (3 Sigma) [wt.%]
Oxygen	31.75	46.16	61.82		0.00	12.30
Silicon	12.25	17.80	13.58	SiO2	38.09	1.66
Aluminium	6.29	9.15	7.27	Al2O3	17.29	1.00
Sodium	3.26	4.74	4.42	Na2O	6.39	0.75
Magnesium	1.29	1.87	1.65	MgO	3.10	0.32
Sulfur	4.69	6.82	4.56	SO3	17.03	0.60
Calcium	5.09	7.40	3.96	CaO	10.36	0.55
Potassium	1.64	2.39	1.31	K2O	2.88	0.25
Iron	2.26	3.28	1.26	FeO	4.22	0.32
Titanium	0.27	0.40	0.18	TiO2	0.66	0.13
Total:	68.80	100.00	100.00			

V. CONCLUSIONS

Findings of the experiment are:

1. Cantabro loss will be decrease with increasing in asphalt content, and decreasing in proportion of coarse aggregate in mix.
2. Air void will be increase with decreasing in asphalt content, and increasing in proportion of coarse aggregate in mix.
3. Loss of running off will be increase with increasing in asphalt content, and increasing in proportion of coarse aggregate in mix.
4. The Japan's method resulted lower optimum asphalt content and higher dynamic stability compare to the Japan's method, although it is required more evidence.
5. Permeable asphalt pavement mixture for Cantabro test we can see that optimum BNA Blend Pertamina for the coarse agregate domato stone it was bigger porous when quality asphalt 3%. Loss weight Cantabro 77.10% correlation with quality asphalt 3%, loss weight Cantabro 2,34% correlation with quality asphalt 3.5%, loss weight Cantabro 14,56% correlation with quality asphalt 4%, Loss weight Cantabro 12,24% correlation with quality asphalt 4.5% and loss weight Cantabro 9,70% correlation with quality asphalt 5%.
6. This study evaluated the performance of two porous pavement systems from the perspective of infiltration and runoff, with very positive performance in comparison to a traditional impervious surface. All two porous pavement surfaces increased infiltration and decreased runoff. Larger porosity values, higher infiltration coefficients, thicker subbase layers and lower initial water contents of the subgrade produce higher infiltration rates and smaller runoff coefficients. When rainfall infiltrates into a porous surface and its underlying sub-base, the outflow hydrograph will be influenced by the way in which the construction materials retain or delay flow.
7. For quality asphalt 3% we get peak load 15,48 KN Stress 19.703 N/mm^2, for quality asphalt 3,5% we get peak load 10,28 KN Stress 13.093 N/mm^2, for quality asphalt 4% we get peak load 15,26 KN Stress 19.417 N/mm^2, for quality asphalt 4,5% we get peak load 9,90 KN Stress 12.601 N/mm^2, for quality asphalt 5% we get peak load 10,38 KN Stress 13.223 N/mm^2, for quality asphalt 5,5% we get peak load 13,48 KN Stress 17.159 N/mm^2.

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