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SUITABILITY OF RE-COMPACTED FLY-ASH-SLAG-SOIL MIXES FOR CONSTRUCTION OF ROAD PAVEMENT

Summary

Forest communication network consists mainly of dirt roads. Technical problems with forest roads transport occur especially for these dirt roads which are constructed on cohesive topsoil. Lignite fly-ash may be utilized for successful stabilization of cohesive topsoil dirt roads. The pavements stabilized with fly-ash often perform unsatisfactorily under heavy loads and failures are noted as a result. The research described in this paper aimed at developing technical solution for reconstruction of road pavements constructed with admixture of fly-ash and fly-ash-slug respectively. Bearing strength variability of fly-ash-soil and fly-ash-slag-soil mixes after failure and application of repair method were considered. Crushed then re-compacted with addition of stabilizer soil mixes as influenced by period and conditions of binding were tested. The stabilizers utilized for testing were both active fly-ash of lignite group IIIC and coke blast furnace slag. Two varieties of mixes were tested. These varieties were sandy clay mixed with addition of 14 % lignite fly-ash and the mixture of 10 % lignite fly-ash and 10% furnace slag respectively. The samples were crashed and re-compacted after 14- and 42-day period of curing in optimal and air-dump conditions. After sample curing deformation modules were measured with the utilization of VSS press. The deformation module measurement procedure was the basis for assessment of the mixtures suitability for reconstruction of forest road pavements after failure. Higher bearing performance especially after air-dump curing occurred for sole fly-ash addition mix varieties. The technical guidelines for reconstruction of road pavements with utilization of re-used crashed pavement materials were developed as well. The clayey pavements after failure may be stabilized again in fortnight period after construction. The repair procedure includes re-compaction and watering to achieve optimum moisture content. In addition, the optimum doses of stabilizer content for the reconstruction after longer than forthright period since the road construction were identified.

Key words: forest dirt road, stabilization, fly-ash, slag, pavement reconstruction technical guidelines development

INTRODUCIOTN

Forest communication network consists nearly in 79% of dirt roads. Technical maintaining of these roads to provide good communication conditions for forest transport require frequent road repair and resurfacing. The most frequent technical problems occur for the roads constructed on cohesive and organic topsoil. These soils differ in mechanical properties depending on moisture content. As far as transport loads are concerned the dirt roads constructed of these soils, the increase of moisture stimulates gaining higher plasticity and therefore loosing bearing strength of the road pavement. Thus heavy transport loads on these roads cause destruction of road frame. One of the stabilizers suitable for cohesive soils setting is active lignite fly-ash. Anyway biding strength properties of lignite fly-ash are lower than the cement matrix binding properties. Thus the pavements constructed of lignite fly-ash reach relatively lower bearing strength level after longer time of binding (Kamiński at al. 1986). The pavements constructed of lignite fly-ash in initial 4 to 8 weeks after construction may undergo failure under intensive transport loads. The research described in this paper aimed at developing a technology of road pavement repair or reconstruction after failure. The investigated road pavement materials were fly-ash-soil and fly-ash-slag-soil mixes. Bearing strength variability of crushed then re-compacted mixes as influenced by period and conditions of binding before crushing and after supplementing of stabilizer was investigated.

MATERIALS AND METHODS

Fly-ash tends to reveal the highest binding properties for cohesive soil. The soil selected for tests was sandy clay extracted from topsoil layer of forest dirt road. The stabilizer selected for setting topsoil material was active fly-ash group III subgroup C from power plant Pątnów. Prior to setting half of the samples had grading composition improved by addition of coke furnace slag. The slag admixture was ground to gain grading composition of gravel.

The tests were performed on two types of sandy clay samples. Namely, the sample with sole addition of 14% fly-ash (Gp14P) and the sample with addition of 10% fly-ash and 10% slag respectively. The composition of abovementioned samples was developed by iteration methods. The criterion employed for selection of the soil mixes was the baring strength, thus the samples selected reached the highest strength. The samples were prepared in CBR cylinders. The mixes were compacted with 100% pressure of the Proctor method with optimum moisture content. Each mixture underwent 6 series of tests, including two series of comparative non-destructive tests of samples under curing. One of the test series was performed for the samples curing in optimum moisture conditions (o) and the other in conditions of total saturation (m). Sample curing periods included 14-, 42-, 70-, 98-, 126- and 154-day periods.

The samples binding in optimum moisture conditions (o/14, o/42, ..., o/154) were stored in temperature 18ºC through entire curing period protected against loss of moisture. The saturated samples under damp curing (m/14) were initially stored for 7 days in optimum moisture content then submerged to gain capillary ascent and subsequently entirely submerged for 6 days. The samples tested after the longer period (m/42,..., m/154) were initially cured in optimum moisture content conditions and then14 days before the date of penetration were submerged for 1 day period to gain capillary ascent (level 1) and subsequently totally submerged for the remaining period of 13 days.

After determination of bearing strength of the samples cured in optimum water content and then submerged (o/14*, o/42*, m/14*, m/42*) the samples were crashed and sieved through 8mm sieve to achieve similar graining composition. The samples were re-compacted after supplementing of water to regain optimum water content. The curing pattern applied before crushing was employed after re-compaction again. In order to increase bearing strength there were prepared the series of samples, for which after crushing addition of fly-ash in proportion 4 and 6% was mixed.

The bearing strength of all samples was determined with utilization of VSS press. Deformation modules were measured after two passes of bearing pressure application - primary (E_1) and secondary (E_2). The ratio E_1/ E_2 was calculated (Rolla 1985). Deformation modules were calculated with following formula according to Polish standard (PN-S-02205:1998):

$$E = \frac{\Delta p}{\Delta s} \cdot D \cdot 0,75$$

Δp – increase of unit pressure 0,25 – 0,35 MPa,
Δs – increase of vertical deformation for pressure 0,25 – 0,35 MPa in cm,
D – diameter of pressure plate in cm

RESULTS

Sandy clay mixed with sole lignite fly-ash (Gp14P) gained in series of comparative analysis tests maximum deformation modulus (E_1) equal 150MPa, but after dump curing the modulus decreased by 16% (Table 1). The samples after re-compaction and 14-day period of curing in optimum water content conditions (o/14*) reached lower by 17% deformation modules in comparison with comparative test samples. Re-compacted samples after dump curing (m/14*) had lower deformation modules (E1) in average by 25 to 33% in comparison with corresponding comparative analysis test samples. These samples tested after 42-day period of binding (o/42*) showed even higher decrease of bearing strength in comparison to optimum and dump conditions of curing. Series cured in optimum moisture content had the decrease of maximum deformation modules (E1) by 55%. After dump curing (m/42*) maximum deformation modulus equaled only 50 MPa, therefore the loss of bearing strength was about 60% against cooperative test analysis samples.

Addition of 4% fly-ash to crushed samples cured in dump conditions (m/42*) increased bearing strength by 40 to 50%. The 8% addition of fly-ash increased bearing strength even higher, by extra 30 to 50%. These test result were close to the results of comparative analysis performed in dump conditions.

Table 1. Deformation modules E_1 of sandy clay stabilized with fly-ash (Gp14P) as Influenced by various methods and periods of sample curing

Sample curing described in methodology	Deformation modules E_1 and relation of E_2/E_1					
	Curing period in days					
	14	42	70	98	126	154
Optimum moisture (o)	75,0-1,7	93,7-1,3	107,1-1,2	125,0-1,5	150,0-1,7	150,0-2,5
Dump (m)	68,2-2,2	83,3-1,8	107,1-2,3	107,1-1,7	125,0-1,5	125,0-1,5
Crushed (o/14*)	-	83,3-1,3	83,3-1,8	107,1-1,7	125,0-2,0	125,0-1,5
Crushed (m/14*)	-	62,5-2,4	68,2-2,2	83,3-3,0	83,3-1,8	93,7-2,0
Crushed o/42*)	-	-	44,1-1,7	50,0-1,9	75,0-2,0	68,2-1,6
Crushed (m/42*)	-	-	25,0-3,0	37,5-2,2	53,6-2,8	50,0-3,0
Crushed + fly-ash (o/42*+4P)	-	-	62,5-2,0	68,2-1,8	93,7-1,6	93,7-1,6
Crushed + fly-ash (m/42*+4P)	-	-	41,7-2,0	46,9-2,3	75,0-2,0	75,0-2,5
Crushed + fly-ash o/42*+8P)	-	-	68,2-1,8	75,0-2,0	107,1-1,7	125,0-2,0
Crushed + fly-ash (m/42*+8P)	-	-	57,7-2,2	68,2-1,8	93,7-1,6	107,1-2,3

The tests for fly-ash-slag with sandy clay mix (Gp10P10Ż) crushed after 14- and 42-day curing period returned similar trends of bearing strength decrease as for sole fly-ash admixture (Table 2). Anyway, the mixes stabilized with addition of fly-ash and slag revealed apparent vulnerability to destructive water impact. The samples submerged (damp curing) for the purpose of comparative test analysis underwent 40% decrease of bearing strength. The addition of porous grain of slag resulted in the rise of water absorption and capillary ascent.

The tests described above revealed that the mix Gp14P crushed in initial stage of binding (fortnight period) may be reused for forest road pavement resurfacing. It is recommended to use soil mill to shear and crush topsoil, damp the soil to gain optimum moisture content, damp mix, level then re-compact. In the case if road construction gets damaged after longer period of binding than fortnight it is recommended to mix a dose of 4 to 8% of fly-ash, dry mix, level and re-compact. If the soil before re-compaction has coarse structure the compaction should be performed with vibrating roller [Kamiński *et* Kokowski 1994].

Table. 2. Deformation modules E1 of sandy clay stabilized with mixture of fly-ash and cinder (Gp10P10Ż) as influenced by various methods and periods of sample curing.

Sample curing described in methodology	Deformation modules E_1 and relation of E_2/E_1					
	Curing period in days					
	14	42	70	98	126	154
Optimum moisture (o)	83,3-1,8	107,1-1,4	125,0-1,5	150,0-1,7	187,5-1,3	187,5-2,0
Dump (m)	62,5-1,7	75,0-2,5	75,0-2,0	93,7-2,0	125,0-1,5	107,1-1,4
Crushed (o/14*)	-	75,0-1,4	93,7-1,6	83,3-2,2	107,1-1,7	125,0-1,5
Crushed (m/14*)	-	50,0-2,1	62,5-1,7	75,0-2,0	83,3-1,8	83,3-2,2
Crushed o/42*)	-	-	53,6-2,0	68,2-1,8	75,0-2,0	75,0-2,0
Crushed (m/42*)	-	-	18,7-3,1	25,0-2,7	41,7-2,6	47,5-2,8
Crushed + fly-ash (o/42*+4P)	-	-	83,3-1,8	83,3-1,8	93,7-1,6	107,1-2,3
Crushed + fly-ash (m/42*+4P)	-	-	25,0-3,0	37,5-2,0	37,5-2,9	50,0-3,0
Crushed + fly-ash (o/42*+8P)	-	-	93,7-1,6	107,1-1,7	107,1-2,3	125,0-2,0
Crushed + fly-ash (m/42*+8P)	-	-	46,9-3,2	50,0-3,0	62,5-2,4	75,0-2,5

CONCLUSIONS

1. The sandy clay mixture with 14% addition of fly-ash revealed higher bearing strength than sandy clay mixture with slag and fly-ash. The abovementioned relation was especially apparent in damp conditions.
2. Damaged road pavements constructed with clay stabilized with addition of fly-ash may be repaired by re-compaction after gaining optimum moisture content (to maintain required conditions of compaction) in fortnight period after construction.
3. As for the case if road construction was damaged after longer period of binding than fortnight the soil should be milled, mixed with a dose of 4 to 8% of fly-ash (dry proportion), moistened to reach optimum moisture content, leveled according to technical specifications and re-compacted. If the soil before re-compaction has coarse structure the compaction should be performed with vibrating roller.

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