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Replacing Cattle Manure Ash as Cement into Concrete

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Abstract: Chemical properties and the pozzolanic effects of partial replacement (0, 5, 10, 15, 20, 25 and 30%) of cement with Cattle Waste Ash (CWA) were investigated in concrete. Concrete samples were tested physically, mechanically at the age of 3, 7, 14, 28 and 56 days of the experiment. Test results indicated that for an increase in waste ash content there was a general decrease in compressive strength for all concrete mixes. However, the difference among the 3 day compressive strength of specimens increased with increasing ash content. But, at later ages (beyond 14 days), this difference diminished when compared to the control mix. The 56-day compressive strengths of samples with 5, 10 and 15% CWA provided the best results, which were determined as 96, 95 and 94% of the control's value, respectively.

Key words: Cattle waste ash, pozzolanic, concrete, binder, manure

INTRODUCTION

According to the 2000 census, the total population of Turkey is about 67 millions and 804 thousands. It was noted that 35% of the population resided in rural areas (Ozgur, 2003). Various traditional energy sources are used in rural houses in Turkey. For heating, the sun dried cattle manure is mostly consumed in villages except for those close to the forest regions (Gokmen *et al*., 2004). Fuelwood, animal wastes, agricultural crop residues and logging wastes have been used many years for direct burning in Turkey (Demirbas, 2001).

A significant development in the cattle production in many countries has been a change from pasture grazing to raising cattle on an industrial basis in feedlots. While this has given great benefits to farm owners, the increasing amounts of waste produced from this intense form of cattle production has come under heavy environmental scrutiny. The current practice of waste management is to stockpile the waste for a period of time and then spread it over available land (Thomas and Patnaikuni, 1998). Each cattle leaves approximately one ton of collectible biomass over a five month period. In many cases, the production of manure from one or more cattle species is in excess of what can be safely applied to farmland in accordance with nutrient management plans and the stockpiled waste poses economic and environmental liabilities. Along with the increasing environmental concerns, the non-availability of suitable sites for cattle waste disposal has created enormous problems for feedlot managers. Considering the above factors, disposing the waste through incineration is a viable solution. However, the problem still exists with the ash generated from the incineration process. Other research conducted in the past utilizing waste materials such as fly ash, rice husk ash, sewage sludge ash and other incinerator residues in cement based materials has provided some promising result (Malhotra, 1993). Due to its pozzolanic nature, fly ash is a beneficial mineral admixture for concrete. It influences many properties of concrete in both fresh and hardened state (Malhotra and Mehta, 2002). Extensive research has shown that pozzolanas can produce concrete having almost the same behavior as normal concrete at ages beyond 28 days (Marina *et al*., 1988). Bellizia *et al*. (2002) investigated the viability of utilizing cattle waste ash produced different temperatures and durations. They shown that was able to used as binder in concrete of cattle waste ash produced an optimum temperatures of 600°C of 2 h duration.

The consumption amount of the sun dried manure as major energy source in rural houses is 5439 kton, which has a 15.4% proportion of energy sources used in the households in rural areas of Turkey (Anonymous, 1999; 2003). On the other hand, there was no data reported about the binding effects of CWA for concrete in Turkey. Therefore, this study was conducted to test the pozzolanic properties of ash and evaluate effects of CWA upon the physical and mechanical properties of concrete.

MATERIALS AND METHODS

CWA was obtained from rural houses used for heating. It was ground to fine powder to pass through a 212 μm sieve and was used to replace 5, 10, 15, 20, 25 and

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30% by mass of Portland composite cement content in all concrete mixes. A control mix (0% cement replacement) was also included to monitor the pozzolanic activity of each mix.

The physical and chemical properties of the Cement (CEM II /B-M 32.5) and CWA are summarized in Table 1.

A natural river sand and crushed limestone were used as fine and coarse aggregates. The total cementitious materials content and the water/binder ratio were kept constant at 348 kg m^{-3} and 0.54, respectively. Concrete mixture proportions are shown in Table 2.

Fresh concrete specimens were cast into cylindrical metal moulds (150/300 mm). The hardened specimens were tested for compressive strength. For this purpose, a total of 105 cylindrical specimens were cured in lime- saturated water at a temperature of 20±2°C. Compressive testing was carried out at 3, 7, 14, 28 and 56 days after casting. All tests were performed as three replicates.

Table 1: Physical, chemical and mechanical properties of cement and chemical structure of CWA

Chemical composition (%)	Cement	CWA*
SiO_2	26.14	41.70
Al_2O_3	6.34	6.23
Fe_2O_3	4.08	4.33
CaO	49.13	18.20
MgO	2.99	7.33
Na_2O	0.55	2.58
K_2O	0.67	8.62
SO_3	2.26	2.57
Loss on ignition	6.80	2.30
Insoluble residue	1.05	-
Free CaO (%)	0.12	4.30
Physical properties of cement		
Specific gravity	2.86	
Initial setting time (min)	206.00	
Final setting time (min)	267.00	
Compressive strength (MPa) of cement		
2 days	16.90	
7 days	28.40	
28 days	39.00	

*Cattle waste ash

Table 2: Concrete mixture proportions with CWA

	Replacement (%)						
	0	5	10	15	20	25	30
Cement (kg m^{-3})	348	330.6	313.2	295.8	278.4	261	243.6
CWA (kg m^{-3})	0	17.4	34.8	52.2	69.6	87	104.4
Water (kg m^{-3})	188	188	188	188	188	188	188
Water/Cement	0.54	0.57	0.60	0.64	0.68	0.72	0.77
Water/binder	0.54	0.54	0.54	0.54	0.54	0.54	0.54
Fine aggregate (kg m^{-3})	747	747	747	747	747	747	747
Coarse aggregate (kg m^{-3})	912	912	912	912	912	912	912
Unit weight in fresh state (kg m^{-3})	2273	2270	2265	2259	2255	2248	2241

RESULTS AND DISCUSSION

The physical, chemical and mechanical properties of the cement and chemical properties of CWA (Table 1) and compressive strength values of the concrete samples based on curing ages were presented in Table 3.

It can be seen from Table 1 that the total percentage of $SiO_2 + Al_2O_3 + Fe_2O_3$ was 52.26%, which was greater than the minimum (50%) specified as Class C in ASTM C-618. Combined silica and alumina content, which contributes to the pozzolanic activity by reacting with calcium hydrated in the Portland cement, was found as 47.93% for the CWA. This value was lower than that of 79.95% reported by Bellizia *et al.* (2002). This determined low pozzolanic activity may show that ash produced was not burnt at proper conditions.

The results of compressive strength of test specimen with different ash contents and with different periods of water curing are shown in Fig. 1 and 2. Figure 1 shows the effect of curing on compressive strength at different ages. Depending on the period of curing increases, the difference in strength between the control mix (0% ash) and the mixes with various percentage replacements tends to get smaller. On the other hand, Fig. 2 shows that the compressive strength decreases with increasing amount of CWA content. Besides, Fig. 3 representing the pozzolanic activity index for all mixes containing CWA is the ratio of compressive strength between concrete samples containing waste ash and the control. The results

Table 3: Compressive strength for concrete mixes with CWA

	Compressive strength (MPa)				
Ash (%)	3 days	7 days	14 days	28 days	56 days
0	11.9	14.8	16.4	21.4	23.0
5	10.7	14.0	15.4	21.0	22.0
10	8.4	9.6	15.2	20.4	21.8
15	8.3	9.2	14.9	20.0	21.7
20	8.2	8.9	14.2	20.6	21.2
25	7.8	8.5	13.1	19.2	20.1
30	7.3	7.8	12.6	17.8	19.3

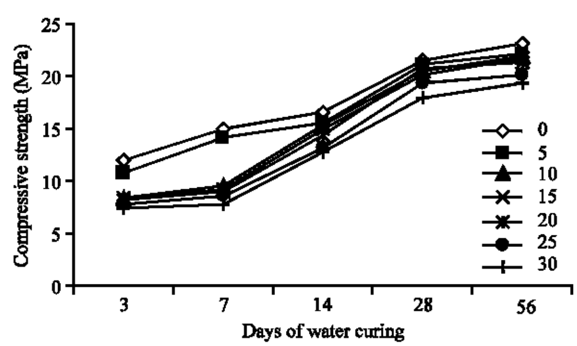

Fig. 1: Compressive strength of concrete with different proportions of CWA

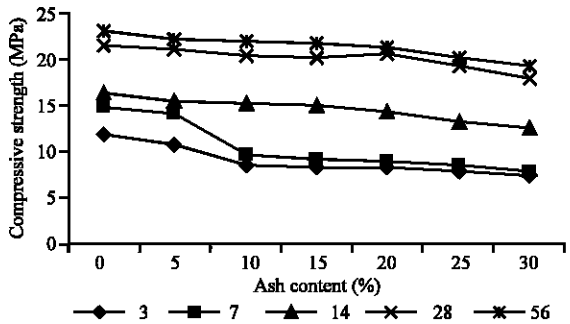

Fig. 2: Compressive strength of concrete with different proportions of CWA

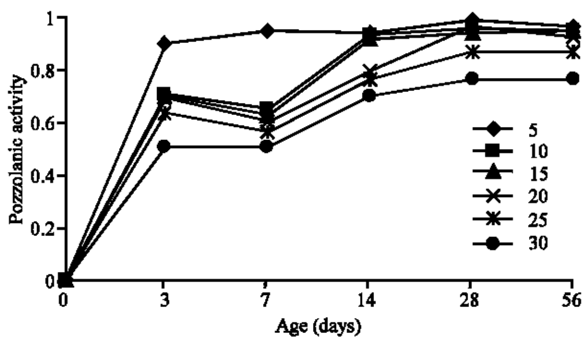

Fig. 3: Pozzolanic activity for concrete with different proportions of CWA

show that the 3 day compressive strength decreased sharply with increasing ash content. However, at later ages (beyond 14 days), this difference diminished. The control specimen (0% ash) yielded the compressive strength of 23 MPa at 56 days. Specimens having 5, 10, 15, 20 and 25% of the cement content replaced by ash provided the compressive strength reaching 22, 21.8, 21.7, 21.2 and 20.1 MPa at 56 days, respectively. Sample with 30% CWA gave the lowest compressive strength, a difference of 16% when compared to the control mix at 56 days. This process of strength development is expected to continue with curing time until completion of hydration of the cement-ash mixture.

CONCLUSIONS

The present study showed that ash of the sun dried cattle manure can be successfully used as pozzolana in concrete. The ash used had 52.26% by mass of $S_iO_2 + Al_2O_3 + Fe_2O_3$. The 56 day compressive strengths of samples with 5, 10 and 15% CWA provided the best results, which were determined as 96, 95 and 94% of the control's value respectively. However, samples containing various proportions of ash showed low compressive strength compared to the control, suggesting their use in concrete works where the compressive strength requirement is of little importance. Most of the buildings in the rural areas consist of low quality traditional materials. Many families living in rural hoses don't afford to build from quality material their hoses, which are poor families. Therefore, families living in rural areas can utilize cattle manure ash as binder to produce a low-cost and quality material.

REFERENCES

Anonymous, 1999. State Institute of Statistics (SIS). Statistical Yearbook of Turkey. Prime Ministry Republic of Turkey, Ankara, Turkey.

Anonymous, 2003. World Energy Council Turkish National Committee (WECTNC). Energy Balances. Ankara, Turkey.

Bellizia, R., P.R. Thomas and I. Patnaikuni, 2002. Cattle feedlot waste ash blended cement in concrete and mortar. J. Solid Waste Tech. Mange., 28: 182-188.

Demirbas, A., 2001. Energy balance, energy sources, energy policy, future developments and energy investments in Turkey. Energ. Convers. Manage., 42: 1239-1258.

Gokmen, A., S. Kayaligil, G.W. Weber, I. Gokmen, M. Ecevit and A. Surmeli *et al.*, 2004. Balaban valley project: Improving the quality of life in rural area in turkey. Intl. Sci. J. Meth. Models Complex., Vol: 7.

Malhotra, V.M., 1993. Fly ash, slag, silica fume and rice husk ash in concrete. A Review. Concrete Intl. Design Construc., 15: 23-28.

Malhotra, V.M. and P.K. Mehta, 2002. High-Performance, High-Volume Fly Ash Concrete, Supplementary Cementing Materials for Sustainable Development. Marquardt Printing, Ottawa.

Marina, A., S. Julian and V. Janer, 1988. Properties of concrete made with fly ash. Intl. J. Cement Compos. Lightweight Concrete, 10: 109-120.

Ozgur, E.M., 2003. La Population de la Turquie au début de XXI Siècle, Cografi Bilimler Dergisi, 1: 43-53.

Thomas, P.R. and I. Patnaikuni, 1998. Farm cattle waste ash recycling strategy in construction. Proceedings of the International Symposium on Innovative World of Concrete (IWC-98), November 16-19, Oxford and IBH Publishing Co. Pvt. Ltd., pp: 91-98.