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Civil and Structural Engineering

Highlights

Road Pavement Layers

Rajbandh Sanitary Landfill

Bond Stress of Reinforceds

Civil Engineering Significant

Discovering Thoughts, Inventing Future

VOLUME 13 ISSUE 2 VERSION 1.0

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Investigation into Effects of Construction Moisture Content on Inerted Manganese Product Stiffness in Road Pavement Layers

By J. Strydom & WJvdM Steyn
University of Pretoria, South Africa

Abstract - The use of waste materials from various processes as pavement layers has long been an option for disposing of such materials. Huge volumes of material are typically required to construct pavement layers and this option provides the opportunity for disposing of large volumes of materials without requiring landfill areas. Electrolytic Manganese Dioxide (EMD) is produced in South Africa from manganese ore through the process of electrolysis. Belt filter residue from the EMD production residue is thixotropic, and is dried by adding lime. The dried product is known as Inerted Manganese Product (IMP). IMP has been used successfully in pavement layers in South Africa. Uncertainty regarding the optimal Construction Moisture Content (CMC) led to research where five sections with IMP base layers were constructed at different CMCs, followed by monitoring of both short-term and long-term stiffness development in the layer. Data analysis consisted of evaluation of changes in base layer stiffness, focusing on the effect of the differing CMC contents. The paper covers the experimental design, data collected and analyses, leading to conclusions regarding the optimal CMC required to obtain optimal short-term stiffness in the IMP-constructed base layer.

Keywords : stabilization, inerted manganese product, behaviour, stiffness.

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J. Strydom [α] & WJvdM Steyn [σ]

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I. Introduction

The use of waste materials and by-products from various processes and sources as road pavement layers has long been one of the options of disposing of such materials. As huge volumes of material are typically required to construct pavement layers, this option provides the opportunity for disposing of large volumes of materials without requiring landfill areas. It has always been important to ensure that such materials adhere to the minimum engineering specifications required for the specific layer in which it was to be used, that there are no health and safety issues that could lead to pollution of the environment and population and that it still provides a cost-effective option for the road construction.

Author α : Civil Engineer, Unversity of Pretoria/Aurecon Center, South Africa, 0081. E-mail : Jodi.Strydom@aurecongroup.com
Author σ : Professor of Civil Engineering, University of Pretoria, Lynnwood road, Pretoria, South Africa, 0002.
E-mail : wynand.steyn@up.ac.za

Mining is another activity that contributes to the depletion of natural resources. Mined material is processed to produce useable products. Waste (which is often hazardous to the environment) is produced in the process. If no use is found for the waste it is disposed of at waste disposal facilities. However, when waste is used as road building materials, natural resources are saved and the waste piles at waste disposal sites become smaller and may ultimately disappear. It is clear that the responsible use of waste in road construction potentially has major environmental advantages [1].

Electrolytic Manganese Dioxide (EMD) (used in the production of batteries) is produced in South Africa from manganese ore through the process of electrolysis. Inerted Manganese Product (IMP) originates from EMD waste. When EMD is produced, "manganese containing belt filter residue" is also produced. The belt filter residue is thixotropic, meaning that when the residue is stirred, it becomes liquid. The residue is dried by adding lime to it. The dried product is known as IMP [2]. The pH of the IMP is in the order of 12 and it poses a chemical hazard. IMP delists to a general waste in South Africa and is typically disposed of at designated waste disposal facilities. The production of IMP in South Africa amounts to approximately 35 000 tons per year, and it is slowly increasing [3]. Due to the well-controlled industrial process that leads to the production of the IMP, the produced material is consistent in quality and properties. Use as selected, subbase and base layer (combined 450 mm thickness) in a normal single lane road translates this to construction of around 98 km of road per year.

Continued disposal to landfills requires expansion of existing waste disposal facilities. This is not preferable in terms of environmental considerations. In 2002 the Department of Water Affairs and Forestry (DWAF) approved the use of IMP as a road building material under the following conditions:

- The IMP layer must be sealed;
- The volume of IMP per area must be limited to 2 400 tons/hectare, and
- The use of the material must be controlled and monitored [4].

In 2007, Komatiland Forests (Pty) Ltd constructed the first road using IMP [3]. The road is located at the Brooklands plantation in Mpumalanga and is 7.9 km long. Three 150 mm layers of IMP were used as the base, subbase and selected layers with the in-situ material used as subgrade. Standard engineering properties of the IMP were evaluated prior to the construction of the road. The IMP layers were field compacted at the Optimum Moisture Content (OMC) of 26.4 per cent. Good compaction was attained but the IMP layer appeared brittle after a while. During further construction of the pavement it started to rain and the moisture content of the IMP layer increased to a value well above the OMC. The compaction results appeared much better at this increased moisture content. The IMP layer became harder, to such an extent that the grader was unable to finish the layer. The tracks of the roller were imprinted on the layer and the layer had to be smoothed by the addition of a thin IMP layer on top of the uneven, compacted layer. After completion of the base, the road was left to cure for approximately 90 days before it was sealed with a 6 mm bituminous slurry seal. It is suspected that the high dosage of lime added to the residue to dry it at source affected the moisture content of the material. The IMP layer gains strength and shows improved compactability, probably due to a pozzolanic reaction between the constituents of the IMP and the lime (CaO) used to dry the IMP.

As the compaction results appeared better at a moisture content above OMC, it was decided to compact the IMP for the remainder of the projects at a moisture content of 30 per cent. Although this provided good compaction, it was unknown whether the 30 per cent moisture content was optimal. If it is still too low, the IMP layers will still not be at optimum strength. If it is too high, water may be wasted during construction. Research was conducted to evaluate the effect of a range of moisture contents on the properties of the IMP.

The objective of this paper (based on a phase of the research) is to determine the effect of the construction moisture content on the short-term stiffness of the IMP used as a base layer in a pavement.

The impact of IMP on the environment was excluded from this study, as it was done in a separate phase of the research and it was found that no negative environmental effects exist as long as the material is used under controlled conditions [2]. The effects of traffic loading on the IMP layers are also excluded from this paper, as the potential for carrying moderate amounts of traffic was already proven in the field, provided that it has been compacted sufficiently [3].

This research will contribute to the understanding of the behaviour of the IMP when it is used as a pavement material, ensuring that it can be used efficiently in this application, where no wastage of water will occur and optimal stiffness and strength will be achieved. It will also enable protection of natural resources that would have been used in the place of IMP and save the effort and costs of disposing of the material at designated waste disposal facilities.

Previous research has shown that the IMP is suitable for use as base and subbase material in a pavement [2; 4]. The amount of IMP must be limited to 2 400 tons per hectare. Assuming a 100 m long road section, 8 m wide, running through the length of a hectare, a pavement with three 150 mm thick layers of IMP with a density of 1 500 kg/m^3 will amount to 540 tons of IMP. This is less than a quarter of the allowable amount of IMP. The permeability and leachability of the IMP is very low due to the fact that the belt filter residue is treated with lime. The leachability is considerably lower than that of many other common construction materials such as ordinary Portland cement [2].

The paper covers the experimental design, the data collected and the analyses of these data, leading to conclusions regarding the optimal moisture content required to obtain optimal short-term stiffness in the IMP-constructed base layer. The long-term stiffness data will be collected in an extension of the project.

II. Experimental Design

Five test sections were constructed at different moisture contents (OMC = 26.4 per cent) as indicated in Table 1. The moisture contents were selected based on field experience indicating viable moisture content values to enable adequate compaction. Test sections consisted of a 5 m long, 1 m wide and 150 mm thick IMP layer, on top of compacted in-situ material. In practice the IMP layers are sealed with a bituminous surfacing, however, the reported sections were constructed and evaluated without this surfacing, as a curing period of ninety days is typically allowed and the duration of this study was less than 90 days. The layout of the test sections is shown in Figure 1.

The in-situ material was compacted with a Bomag BW 70 tandem vibratory roller to ensure good support conditions. After compaction of the in-situ material, the IMP was imported and mixed with water using a Rotovator. The IMP was compacted using 17 roller passes on each test section with the Bomag BW 70 tandem vibratory roller. The test sections were covered with a plastic sheet for the first 7 days after construction, as there were still some rainy days (the experiment was conducted towards the end of the rainy season).

Decagon 5TE moisture and temperature sensors were installed horizontally at mid-depth (75 mm) in each of the sections together with i-buttons. These were continuously monitored at 15 minute intervals over a period of 84 days. Seismic layer stiffness was measured using a Portable Seismic Pavement Analyzer (PSPA) [5] while the elastic surface deflection was measured using a Dynatest Light Weight

Deflectometer (LWD) twice a week (3 repeat measurements of each at each test point). In situ density of the IMP base layers was monitored twice a week using a CPN MC-3 Portaprobe strata gauge, while gravimetric moisture samples were taken at the start and end of the project. Weather data for the testing period was obtained from a nearby station of the South African Weather Services (SAWS). The measured layer stiffness and elastic deflection data were used as the main stiffness indicators for the test sections. The basic engineering properties of the IMP are shown in Table 2 and the grading curve in Figure 2.

III. Data Analysis

The data analysis conducted for this paper consisted of an evaluation of the changes in base layer stiffness over the duration of the project, focusing on the potential effect of the differing construction moisture contents on the short-term stiffness values and densities. In this section the changes in in situ moisture content, seismic stiffness and elastic surface deflection-based stiffness over time for the five sections are discussed.

Evaluation of the dry density values indicates that they ranged between 1 704 kg/m^3 and 1 988 kg/m^3 after construction with no clear correlation with the construction moisture contents. The range decreased towards the end of the experiment with the final dry density values ranging between 1 728 kg/m^3 and 1 876 kg/m^3. The two sections with the lower construction moisture contents had Final Dry Density (FDD) to Maximum Dry Density (MDD) ratios of 1.10, while the two sections with the higher construction moisture contents had FDD to MDD ratios of 1.13 and 1.15.

In Figure 3 the relationship between the in situ moisture content at a depth of 75 mm (middle of base layer) over the duration of the experiment is shown for the five sections. These data indicate variations over the duration of the experiment. Based on the data trend, it appears as if the in situ moisture content is relatively stable. In Figure 4 the relationship between the final in situ moisture content and the construction moisture content as well as optimum moisture contents for the five sections are shown. The average final in situ moisture content was between 84.5 per cent and 89.7 per cent of construction moisture content (except for Section 5 which had the lowest construction moisture content of 22.7 per cent and a final to construction ratio of 108.8 per cent). The final in situ moisture contents were between 86.1 per cent and 94.5 per cent of the OMC. This compares with observations by Emery [6] for the equilibrium moisture content (after at least 2 years) of a base layer in the field under a bituminous surfacing of between 53 and 63 per cent. It can thus be expected that this base would dry out to about 60 per cent over time under a seal and to much lower moisture content in the dry season if unsealed.

The seismic PSPA-measured stiffness values (measured longitudinally) for the five sections are shown in Figure 5. Analysis of the data shows a significant increase in all the stiffness values (after the first approximately 10 days of relatively constant data – sections closed with plastic). The measured stiffness values for Sections 1, 2 and 4 appear to stabilize towards the end of the monitoring. The Coefficient of Variation (CoV) of the data ranged between 0.0 per cent and 35.6 per cent, with the large variations in the initial data. The typical range of CoV data was between 0.6 per cent and 18.9 per cent.

Evaluation of the data in Figure 6 indicates that the seismic stiffness is not directly dependent on the changes in the in situ moisture content over time. While the in situ moisture contents remained relatively constant through the experiment (Figure 3), the seismic stiffness values increased. Statistical analysis indicates that the initial seismic stiffness values had a correlation coefficient of 0.775 with the construction moisture contents, while the final seismic stiffness values only had a correlation coefficient of 0.011.

In Figure 6 the elastic stiffness values based on elastic deflections measured using the LWD are shown for the five test sections. Analysis indicates a general increase in the stiffness values for all sections over the 35 day period. The reason for the slight decrease in elastic stiffness values for Sections 1, 4 and 5 between 6 and 19 days is not clear. It may be related to rainfall that occurred between days 9 and 18, and resultant ponding (due to an uneven surface) of water that was observed on these test sections. The CoV of the data ranged between 0.5 per cent and 28.8 per cent, with the large variations in the initial data. The typical range of CoV data was between 0.6 per cent and 4.8 per cent.

When comparing the potential effect of construction moisture content on these stiffness values, it is observed that the construction moisture content for Sections 2 and 3 were the highest (with the highest stiffness moduli in Figure 6) while the construction moisture contents for Section 5 was the lowest (with the lowest stiffness modulus in Figure 6). The ratio between the final and the original elastic stiffness values for the five sections ranged between 1.1 (Section 5 – lowest construction moisture content) and 2.8 (Section 2– second highest construction moisture content) with a correlation coefficient of 0.69. A correlation coefficient of 0.75 was calculated between the construction moisture contents and the final LWD-based stiffness values, with no correlation between the initial elastic stiffness values and the construction moisture content (correlation coefficient of -0.10).

IV. Potential Applications of IMP

An overview of the stiffness, density and moisture data provided in this paper indicates that the construction moisture content of the IMP plays a significant role in the short-term stiffness values obtained by the IMP in the field. Although this was not clear from the seismic stiffness data, the elastic stiffness and density data indicated the trend.

IMP currently classifies as a G5 material [7] according to its engineering properties (Table 2). However, the measured short-term performance observed in this experiment with increases in stiffness values of between 6 and 185 per cent indicates that the material develops some cementitious bonds during curing. This would be similar to a lightly cemented (C4) material in the TRH14 classification.

The presence of lime in the IMP was verified using Scanning Electron Microscopy (SEM) and Energy Dispersive X-ray analysis (EDX) techniques. In Figure 7 a SEM image of a crack in the IMP (recovered from the test sections after 46 days) is shown with the EDX analysis in Figure 8. The presence of calcium is visible in both locations.

Observation of the elastic stiffness values obtained in the short term (between 100 MPa and 250 MPa) indicates that the elastic stiffness values are still lower than that typically found for C4 layers (between 500 MPa and 2 000 MPa initially), the elastic stiffness values were still increasing when the final measurements were taken. It is expected that the in situ quality of the material is at least similar to a C4 material in the initial equivalent granular condition.

Visual evaluation of the test sections approximately 85 days after construction indicated an extremely hard surface that developed transverse cracks at intervals of approximately 750 mm (Figure 9). These cracks are most probably caused by hydration shrinkage of the base material (initial shrinkage of the original material was 0), as the material cured (and are probably similar in nature to that shown in Figure 7). This type of behaviour supports the motivation to view the material as being similar to a lightly cemented material (C4 according to [7]). It may thus be expected that the IMP will follow the typical behaviour pattern of C4 materials [8], reverting to an equivalent granular material with the on-going application of traffic. This needs to be confirmed through longer-term evaluations of the material performance.

V. Long-Term Behaviour

Although a period of one year is relatively short, the behaviour of the material one year after construction has been evaluated to determine whether any major changes occurred. The test section was not covered during the period, and it thus received all environmental influences and very light traffic (mainly Light Delivery Vehicles at around 10 vehicles per day). In Figure 10 the behaviour of the five sections in terms of elastic modulus after one year is shown. The data indicate that the stiffness values all dropped during this period, and this is most probably due to the stabilization cracks that formed in the layer. The in situ stiffness values are still relatively high, indicating that, despite the stabilization cracking, the material still classifies as a stabilized material [7], and thus should perform well if used in a normal road layer.

VI. Conclusions

The objective of this project was to determine the effect of the construction moisture content on the short-term stiffness of the IMP used as a base layer in a pavement. Based on the information provided in this paper the following conclusions are drawn:

Seismic stiffness values for IMP are initially affected by construction moisture content, although it does not appear to be the case when curing of the material occurs;

- Elastic stiffness values for IMP are affected directly (at least over the short-term) by construction moisture content;
- Elastic stiffness values of the IMP are expected to increase to levels close to those expected from C4 materials. The longer term behaviour of the IMP is expected to be similar to that of C4 materials;
- Higher construction moisture contents appear to lead to increased dry density values, although the differences are not necessarily significant;
- Chemical analysis of the material indicated the presence of calcium compounds (probably linked to the lime added during processing), specifically around internal cracks;
- Final in situ moisture content of the IMP base layer is between 86.1and 94.5 per cent of OMC;
- The long-term behaviourof the material appears to indicate relatively good life to be expected, similar to a normal lightly stabilized layer, and
- The use of waste materials in road construction potentially has major benefits in negating the use of landfills and reducing the requirement for new borrow-pits when constructing roads – leading to the conservation of non-renewable resources.

VII. Recommendations

Based on the discussion and analyses contained in this paper it is recommended that:

The moisture content at which IMP should be compacted during construction is 28 per cent, which is 1.6 per cent higher than OMC, as the section constructed at this moisture content showed the best performance results, and

- Further research into the long-term stiffness development of IMP (longer than the current year), especially as affected by different construction moisture contents, should be continued to ensure that the long-term performance of this material can be adequately described.

Acknowledgements

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Table 1 : Construction Moisture Contents and Dry Densities for Five Test Sections

SECTION NUMBER	CONSTRUCTION MOISTURE CONTENT [%]
1	27.3
2	28.1
3	29.5
4	26.8
5	22.7

Table 2 : Basic Engineering Properties of IMP [7]

ENGINEERING PROPERTY	VALUE
Plasticity Index	NP
Grading Modulus	2.46
Maximum Dry Density [kg/m^3]	1 623
Optimum Moisture Content [%]	26.4
CBR @ 100% Mod AASHTO	117
AASHTO classification	A-1-a
TRH14 classification (TRH14, 1985)	G5

Figure 1 : Layout of experimental test sections

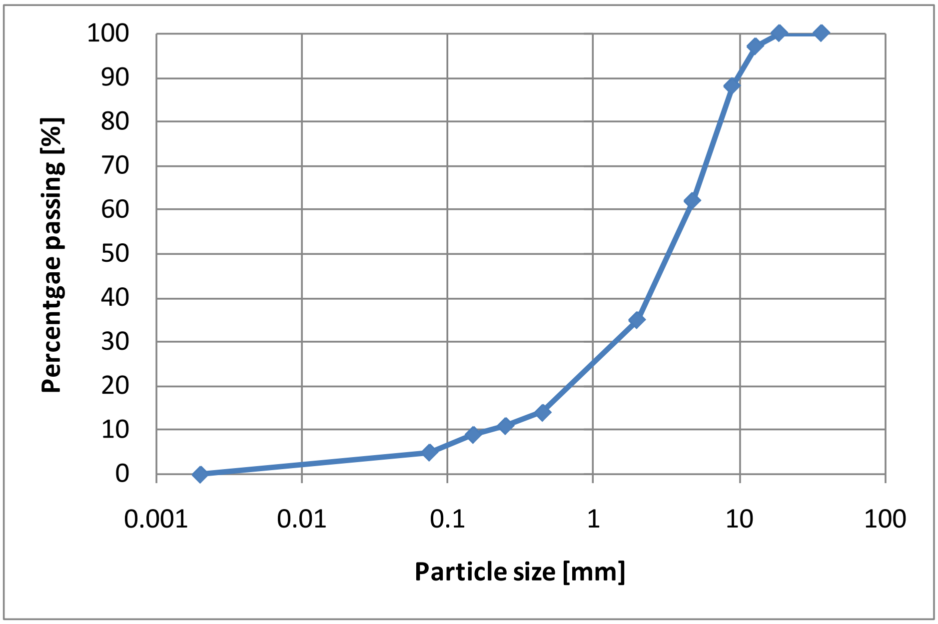


Figure 2 : Grading curve for IMP [7]

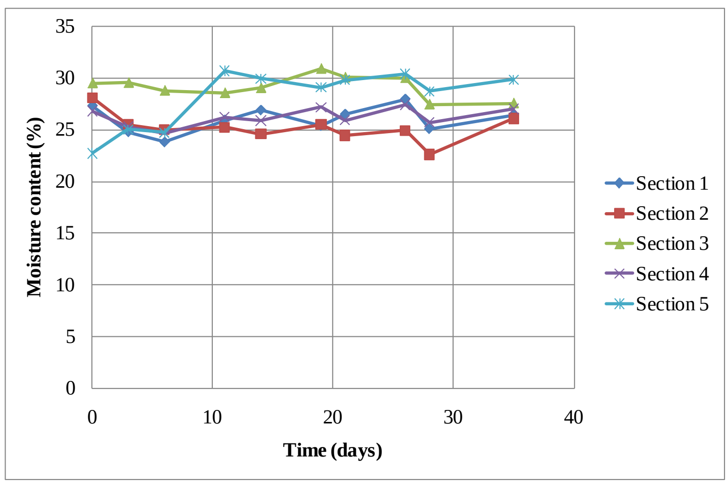


Figure 3 : Relationship between in situ moisture content and duration of experiment for 5 test sections

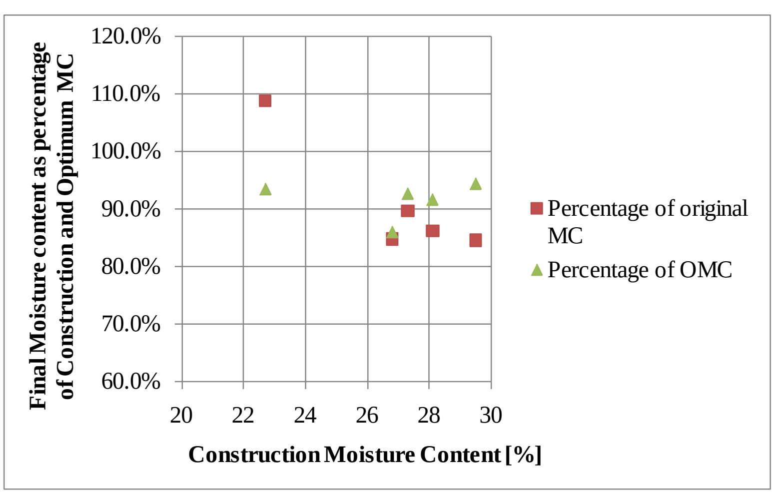


Figure 4 : Relationship between Final in situ moisture content and Construction and Optimum Moisture Contents for 5 test sections

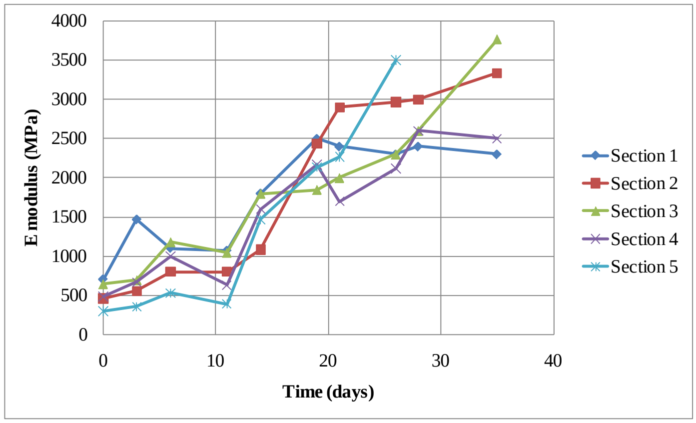
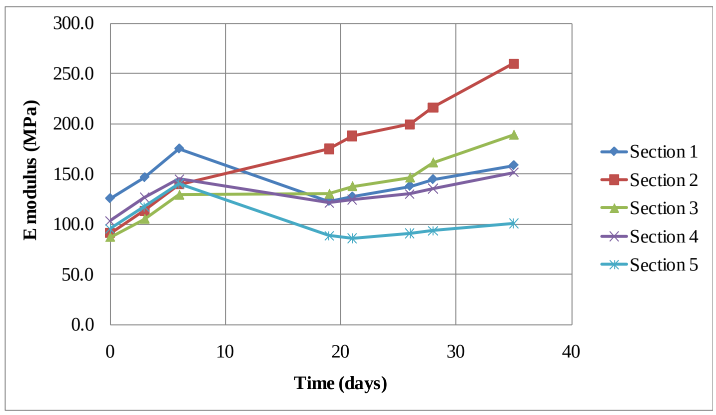
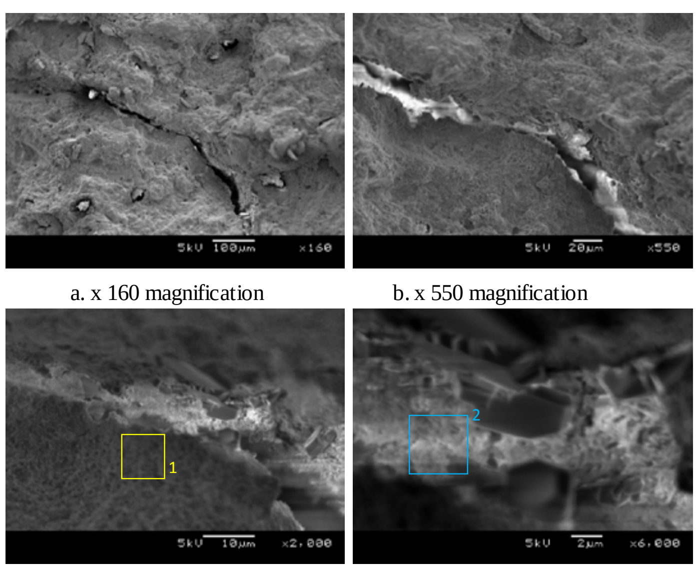


Figure 5 : Relationship between seismic stiffness values and duration of experiment



(no data for Section 5 at 35 days)

Figure 6 : Relationship between elastic stiffness values and duration of experiment



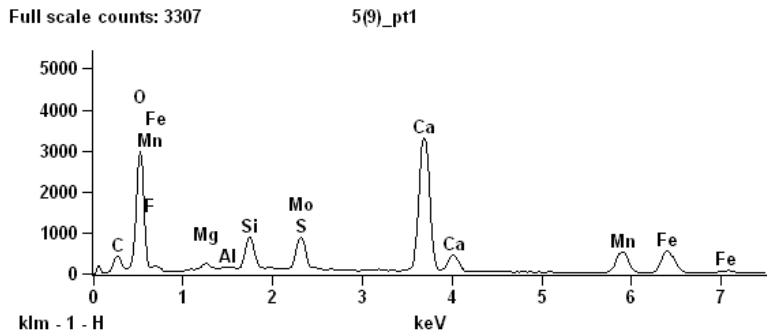
a. x 160 magnification

b. x 550 magnification

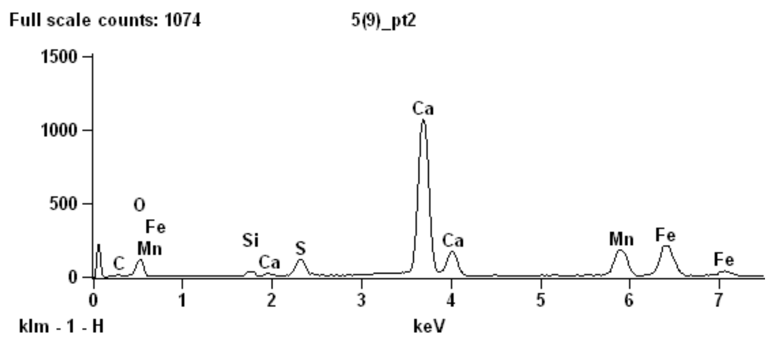
c. x 2 000 magnification

d. x 6000 magnification

Figure 7 : SEM images of a crack in the surface of the IMP sample from Section 5



a. EDX analysis at Location 1



a. EDX analysis at Location 2

Figure 8 : Chemical composition at the locations indicated in Figure 7

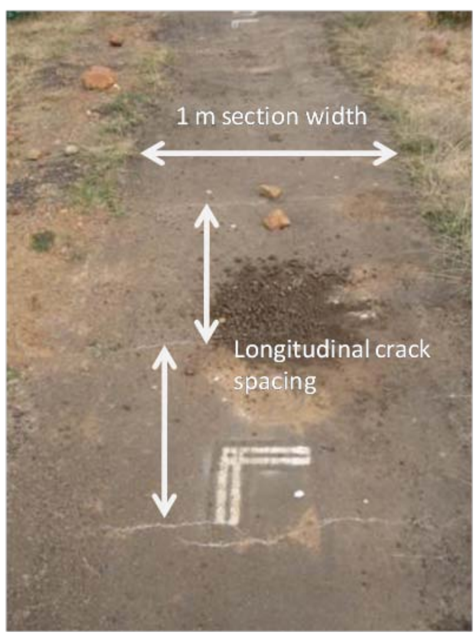


Figure 9 : Appearance of surface of base layer approximately 85 days after construction, showing transverse cracks

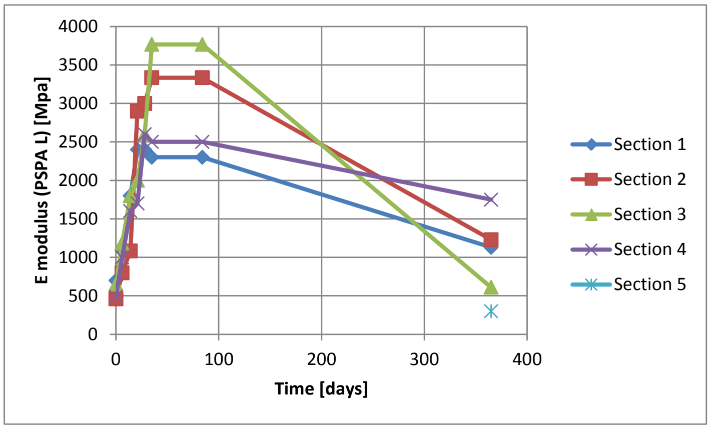


Figure 10 : Relationship between seismic stiffness values and time for long-term evaluation

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Effect of Leachate on Surrounding Surface Water: Case Study in Rajbandh Sanitary Landfill Site in Khulna City, Bangladesh

By Md. Rafiqul Islam, Km Alim Al Razi, Md. Rokon Hasan, Md. Hasibul Hasan & Salma Alam
Khulna University of Engineering & Technology, Bangladesh

Abstract - Leachate is the aqueous effluent generated as a consequence of rainwater percolation through wastes and the inherent water content of wastes themselves. Its quality is the result of biological, chemical and physical processes in landfills combined with the specific waste composition and the landfill water regime. In Khulna city, municipal solid waste is dumped in the Rajbandh landfill site where large amount of leachate is produced every day. This leachate is pretreated by anaerobic process in a pond and pumped out to the surface water from three wells. This pretreated leachate has great impact on surrounding surface water and environment. The aims of this study are to asses and evaluate the environmental impact of the pretreated leachate. In order to do this, some parameters including pH, BOD, COD, Iron content, Alkalinity, TC etc. of the collected leachate and surface water are determined. Obtained values of the parameters are compared with the standard value. Amount of green house gas emission and their effects on human health are also determined and reviewed. Therefore, this paper provides insight regarding how the leachate puts impact to the environment.

Keywords : leachate; bod; green house gas emission; rainwater percolation.

GJRE Classification : FOR Code : 961005, 290802

EFFECT OF LEACHATE ON SURROUNDING SURFACE WATER CASE STUDY IN RAJBANDH SANITARY LANDFILL SITE IN KHULNA CITY, BANGLADESH

Strictly as per the compliance and regulations of :

Effect of Leachate on Surrounding Surface Water: Case Study in Rajbandh Sanitary Landfill Site in Khulna City, Bangladesh

Md. Rafiqul Islam [α], Km Alim Al Razi [σ], Md. Rokon Hasan [ρ], Md. Hasibul Hasan [Ѡ] & Salma Alam [¥]

Abstract - Leachate is the aqueous effluent generated as a consequence of rainwater percolation through wastes and the inherent water content of wastes themselves. Its quality is the result of biological, chemical and physical processes in landfills combined with the specific waste composition and the landfill water regime. In Khulna city, municipal solid waste is dumped in the Rajbandh landfill site where large amount of leachate is produced every day. This leachate is pretreated by anaerobic process in a pond and pumped out to the surface water from three wells. This pretreated leachate has great impact on surrounding surface water and environment. The aims of this study are to asses and evaluate the environmental impact of the pretreated leachate. In order to do this, some parameters including pH, BOD, COD, Iron content, Alkalinity, TC etc. of the collected leachate and surface water are determined. Obtained values of the parameters are compared with the standard value. Amount of green house gas emission and their effects on human health are also determined and reviewed. Therefore, this paper provides insight regarding how the leachate puts impact to the environment.

Keywords : leachate; bod; green house gas emission; rainwater percolation.

I. Introduction

Municipal Solid waste landfill has many adverse effects on surrounding environment. Such landfills often produce leachate, i.e. the liquid that usually drains from landfills due to infiltration by water and/or biogeochemical decomposition processes, which serves as an important point source of pollution in many environmental media around the world. The constituents in leachate, some of which may be toxic, have often posed serious challenges in terms of cost of treatment, accumulation of metal or species, remediation and, in particular, possible eco-toxicological implications resulting from both short- and long-term exposure or bio- accumulation of leachate constituents. (Nyame et al). Leachate is a high strength wastewater that contains high concentrations of organic matter and ammonium nitrogen which results from precipitation entering the landfill and from moisture that exists in the waste when it is disposed. The composition of leachate varies greatly from site to site, and can vary within a particular site. Some of the factors affecting composition include age of landfill, types of waste, degree of decomposition; and physical modification of the waste.

II. Generation of Leachate

Rainfall is the main contributor to generation of leachate. The precipitation percolates through the waste and gains dissolved and suspended components from the biodegrading waste through several physical and chemical reactions. Other contributors to leachate generation include groundwater inflow, surface water runoff, and biological decomposition. Liquid fractions in the waste will also add to the leachate as well as moisture in the cover material (Abbas, 2009).

III. Composition of Leachate

The composition of the landfill leachate varies greatly depending on the age of the landfill. As landfill age increased, organic concentration (COD) in leachate decreased and increase of ammonia nitrogen concentration. The existing relation between the age of the landfill and the organic matter composition may provide useful criteria to choose a suited treatment process (Amalendu, 2004). Bagchi (2004) has tabulated the range of concentration of different parameters in leachate of municipal waste which is shown in table 1. The table describes the lower limits and upper limits that can be expected from the landfill leachates.

Author α σ ρ Ѡ ¥ : Undergraduate student, Department of Civil Engineering, Khulna University of Engineering & Technology, Khulna-9203, Bangladesh. E-mails : mrafiq31@gmail.com, rrr.civil.kuet@gmail.com, semui91@gmail.com, hasibul999@yahoo.com, semui73@gmail.com

Table 1 : Different characteristics of leachate generated from deposited MSW

Physical	Organic constituent	Inorganic constituent	Biological
Appearance pH Oxidation-reduction potential Conductivity Turbidity Temperature Odor	Organic chemicals Phenols Chemical oxygen demand (COD) Total organic (TOC) Volatile acids Tannins , lignin's Organic-N Ether soluble (nil & grease) Methylene blue Organic functional groups as required Chlorinated Hydrocarbon	Suspended solid (SS),total solid(TDS) Volatile suspended solid(VSS) Volatile dissolved solid(VDS) Chloride Sulfate Phosphate Alkalinity & acidity Nitrite-N Ammonia-N Sodium Potassium Calcium Magnesium Hardness Heavy metals(Pb, Cd, Ni,Cr,Co,Zn etc) Arsenic Cyanide Fluoride selenium	Biochemical oxygen demand (BOD) Coli form bacteria (total, fecal, fecal streptococci)

Table 2 : Typical data on the composition of leachate from new and maturation landfill

Constituents	Value (unit)		
	New landfill (less than 2 years)		Mature landfill (greater than 10 years)
	Range	Typical	
TOC(total organic carbon)	1500-20000	6000	80-60
Chemical oxygen demand(COD)	3000-60000	18000	100-500
TSS(total suspended solid)	200-2000	500	100-400
Organic nitrogen	10-800	200	80-120
Ammonia nitrogen	10-800	200	20-40
Nitrate	5-40	25	5-10
Total phosphorus	5-100	30	5-10
Alkalinity as $CaCO_3$	1000-10000	3000	200-1000
pH	4.5-7.5	6	6.6-7.5
Total hardness as $CaCO_3$	300-10000	3500	200-500
Calcium	200-3000	1000	100-400
Magnesium	50-150	250	50-200
Potassium	200-1000	300	50-400
Sodium	200-2500	500	100-200
Chloride	200-3000	500	100-400
Sulfate	50-1000	300	20-50
Total iron	50-1200	60	20-200

There are two options for MSW dumping all over the world, one is crude landfill (open dumping) and the other is sanitary landfill. Sanitary landfill is one of the secure and safe facilities for the disposal of MSW.A pilot scale sanitary landfill is situated at Rajbandh, Khulna in the north side of Khulna-Satkhira Highway and 8 km far from the city center. In Khulna metropolitan city, municipal solid wastes are disposed of at Rajbandh landfill site. In order to pre treat the produced leachate of landfill, firstly it goes to an anaerobic pond for oxidation. Afterwards, it is passed to 15' deep and 4'x4' sized well through pipes. Finally, it is thrown to the adjacent water surfaces. This pretreated leachate mixes with the surrounding water bodies either directly or by rainfall. Despite the pretreatment of leachate, it effects adversely to the surrounding environment and water bodies. So the aim of this study is to evaluate the impact of this pretreated leachate on the surrounding water bodies and characterize the surface water adjacent to the landfill.

The most common pathway for leachate to the environment is from the bottom of the landfill through the unsaturated soil layers to the ground water, then by groundwater through hydraulic connections to surface water. However, pollution may also result from discharge of leachate through treatment plants or direct discharge of untreated or partially treated leachate. The main factors influencing the pollution potential from leachate are:

- The concentration and flux of the leachate
- The landfill sitting, i.e., the hydro geological setting and the degree of protection provided.
- The basic quality, volume, and sensitivity of the receiving groundwater and surface water.

IV. Methodology

a) Field Work

Sample was collected weekly during July to December 2012 for six months. At Each time, total of 8 liters sample was collected in 4, two liters bottles from a distance of 0.25 m at four adjacent sides of the finally pumping out point. Temperature was maintained at 4^0C in each bottle before performing the required tests. Finally, different parameters of the collected sample were determined by performing the laboratory tests.

Table 3 : Location and description of leachate and surface water samples relative to landfill site

Sample No.	Description of Sample Point	Sample Type	Distance (m) from landfill (Reference Pt.)
1	Leachate collection point	Leachate	5m
2	North side of landfill	Surface water	150m
3	East side of landfill	Surface water	150m
4	South side of landfill	Surface water	150m
5	West side of landfill	Surface water	150m

b) Analysis of Leachate and Water Sample

Analytical methods used for leachate and water samples varied depending on the parameters of interest. All field and laboratory determinations were done according to standard methods for the examination of waste and waste water. For every sample, physiochemical, nutrients and oxygen demand parameters were determined. Physiochemical parameters were determined at the Environmental Engineering Laboratory of Khulna University of Engineering and Technology (KUET). Fe and Cadmium were determined by spectrometer.

Biochemical Oxygen Demand (BOD) was determined by diluting portions of the sample and incubating for 5 days at 20°C. The BOD exerted over the 5 days deter-mined as follows:

Calculations

$BOD_5 = BOD \times S1 \times S2$

Where,

BOD_5 = BOD recorded on the fifth day from the Oxitop

S1 = Dilution factor

S2 = Factor dependent on total volume of diluted sample put in Oxitop bottle.

In determining the Chemical Oxygen Demand (COD), the sample was refluxed in concentrated sulphuric acid with a known excess of potassium dichromate ($K_2Cr_2O_7$) for two hours. After digestion, the remaining reduced $K_2Cr_2O_7$ was titrated with ferrous ammonium sulphate to determine the amount of $K_2Cr_2O_7$ consumed and the oxidizable matter calculated in terms of the oxygen equivalent.

V. Results & Discussions

a) Physicochemical Data For Landfill Leachate

Data on parameters from leachate samples taken during the study are presented in Table 4. Average pH value of leachate obtained is 8.15 at a distance of 150 m from the landfill. Throughout the sampling period as well as outwards from the landfill, the pH of leachate remained fairly uniform. Temperature value range from a minimum of 17°C in December at distance 150 m to a maximum of 34.3°C in July at the same sampling site, i.e. 200 m from the landfill. The average value of conductivity 25256µS/cm was obtained in leachate taken respectively in July (distance 150 m) and December (distance 150 m) from the landfill. Average value for total dissolved solids (TDS) was 8906 mg/l at about 150 m from the landfill; Values of other parameters are shown in the following table.

Table 4 : Different parameters of pretreated leachate & the limiting value according to WHO

Pollutant parameters	Average values	Limiting values (according to WHO)
pH	8.15	6.5-8.5
COD	10897 (mg/l)	250
BOD	26000 (mg/l)	50
TDS	8906 (mg/l)	1000
Iron	3.8 (mg/l)	3
Cadmium	4.3(mg/l)	0.003
Sulphate	2960 (mg/l)	400
Nitrate	20(mg/l)	10
Total coliform(TC)	2735 (Nos./100ml)	<400
Conductivity	30000 (µS/cm)	
Chloride	3106(mg/l)	250
Hardness	3789(mg/l)	500

Table 5 : Physico-chemical data from surrounding surface water from 1 week to 26 weeks

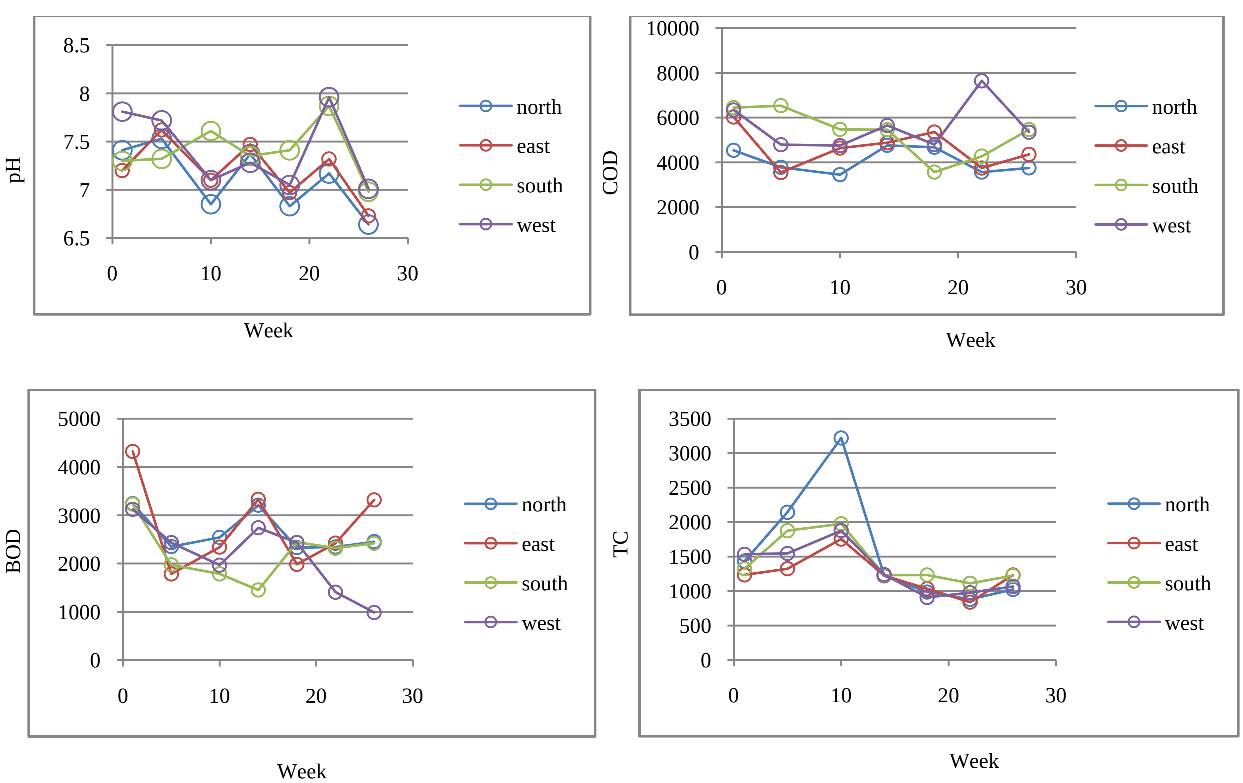
Weeks	1				5				10				14			
Sample	North	East	South	West	North	East	South	West	North	East	South	West	North	East	South	West
pH	7.41	7.2	7.3	7.81	7.53	7.62	7.32	7.72	6.85	7.1	7.61	7.1	7.37	7.47	7.35	7.28
Cond. $*10^3$ (µS/cm)	11.21	13.65	12.54	13.3	15.3	13.78	16.42	14.52	9.78	10.63	13.4	13.1	16.3	17.53	19.23	15.07
TDS (mg/l)	2534	4323	3112	2535	3454	3423	2313	3472	2354	4235	2213	4326	4532	3322	4143	4342
Fe (mg/l)	1.9	2.1	0.7	2.4	3.1	4	0.6	1.3	2.9	1.8	1.4	1.2	1.8	2.3	0.8	1.9
Cd (mg/l)	0.78	0.9	0.47	0.56	0.9	0.78	0.36	0.51	0.89	0.86	0.78	0.73	0.56	0.43	0.45	0.43
Cl^- (mg/l)	1324	1026	1022	987	1026	1132	1423	1324	1862	1322	1324	982	1425	1724	1435	875
Hardness (mg/l)	2453	2422	2212	1244	3321	3473	1212	3266	3533	4552	3215	2166	2313	3453	2533	4233
SO_4^{-2} (mg/l)	1042	1076	1234	876	986	1322	1212	1189	957	1119	1089	1011	1062	1023	975	1342
NO_3^- (mg/l)	14	13.6	14.3	11.6	7.8	10.9	9.9	13.4	15.2	14.8	14.4	11.1	9.6	14.2	11.7	8.9
COD (mg/l)	4536	6023	6443	6342	3780	3546	6532	4785	3450	4636	5472	4745	4759	4875	5458	5643
BOD (mg/l)	3243	4323	3234	3124	2353	1787	1974	2435	2543	2342	1786	1968	3211	3332	1453	2743
TC Nos./100 ml	1432	1234	1323	1533	2143	1323	1875	1545	3221	1754	1976	1876	1221	1223	1231	1238

18				22				26			
North	East	South	West	North	East	South	West	North	East	South	West
6.83	6.97	7.41	7.05	7.17	7.32	7.87	7.96	6.64	6.73	6.98	7.01
19.7	20.01	22.12	14.23	17.24	15.53	16.43	12.32	13.98	12.34	13.43	13.96
3453	4431	3425	5643	2134	4241	3983	4231	2133	2334	5364	4352
0.9	0.9	1.3	3.6	1.1	1.4	2.1	2.3	2.1	1.9	2.5	2.4
0.45	0.76	0.65	0.47	0.8	0.59	0.56	0.35	0.67	0.72	0.68	0.57
1973	1231	1224	1425	986	1322	1423	1325	1423	1422	1342	1342
1023	2124	3132	1212	1239	2311	2331	1223	2123	3211	2331	1543
983	1323	878	1067	1211	1078	979	1083	1089	1028	1094	1312
8.7	12.4	10.7	12.5	12.3	13.2	15.3	13.4	15.2	13.8	12.3	12.9
4673	5354	3564	4787	3564	3745	4275	7642	3752	4356	5467	5345
2332	1985	2442	2435	2345	2424	2319	1407	2456	3321	2422	987
986	1032	1233	906	879	838	1112	975	1023	1232	1223	1065

b) Physicochemical Data for Surrounding Surface Water

From the above table values obtained for pH ranged from 6.64 – 7.81 temperature 27.8°C - 31.2°C, conductivity 610 - 1903 µS/cm, TDS 2213 - 4532 mg/l. Fe ranged from 0.9 – 4mg/liter. Chloride and total hardness also ranged from 987 - 1724 mg/l, 1000 - 5000 mg/l, respectively.

Graphical Representation



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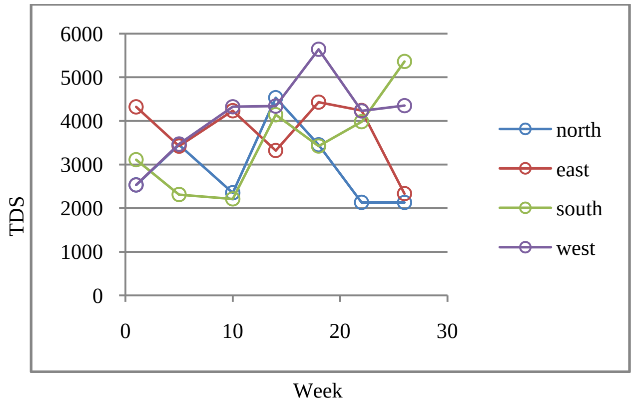
TDS
Week
north
east
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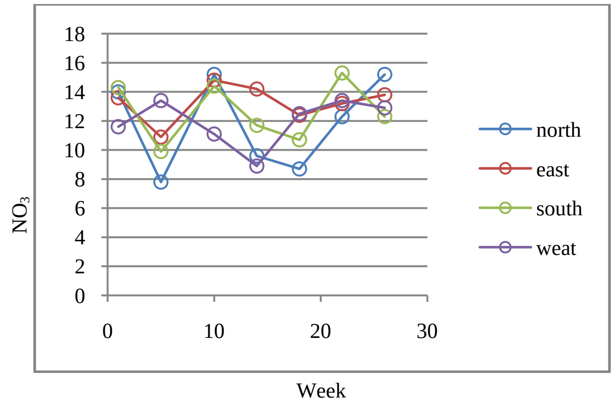
NO_3
Week
north
east
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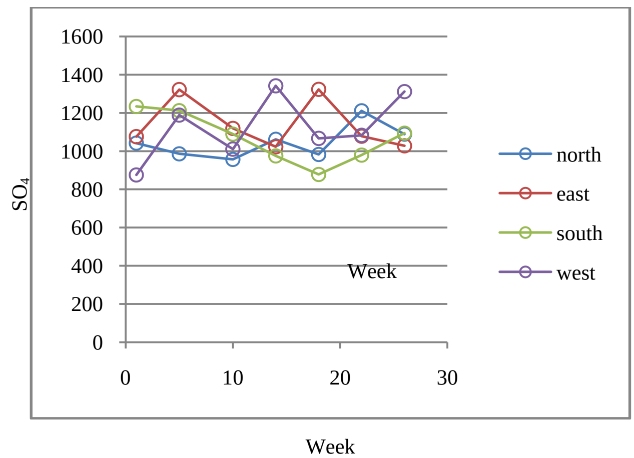
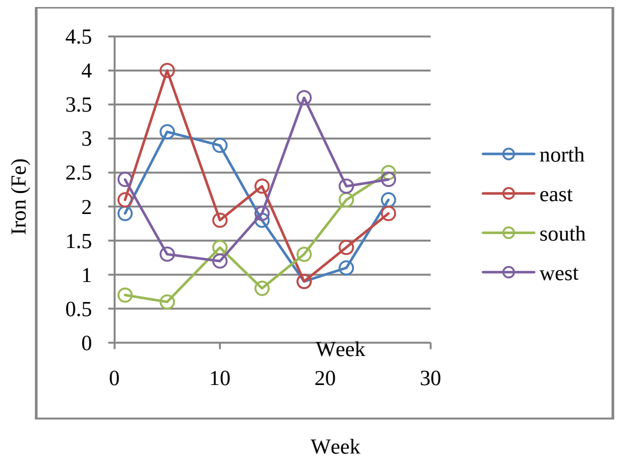
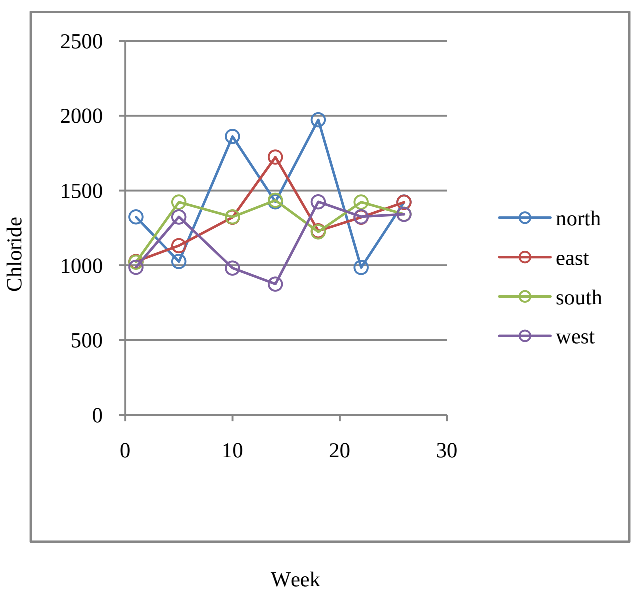
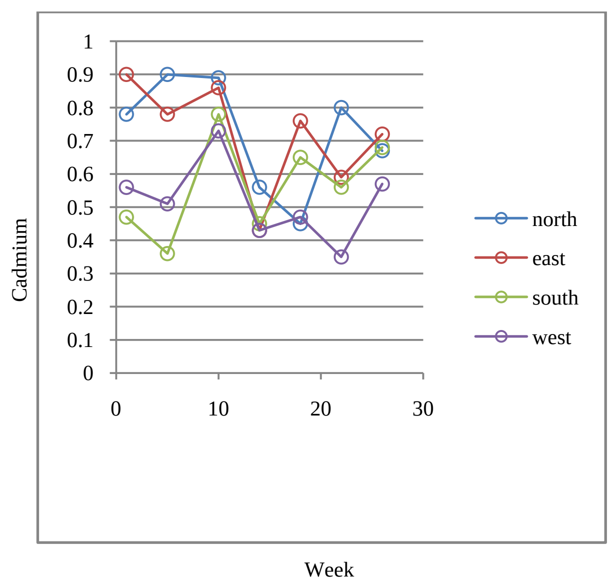
weat


SO_4
Week
Week
north
east
south
west


Iron (Fe)
Week
Week
north
east
south
west


Chloride
Week
north
east
south
west


Cadmium
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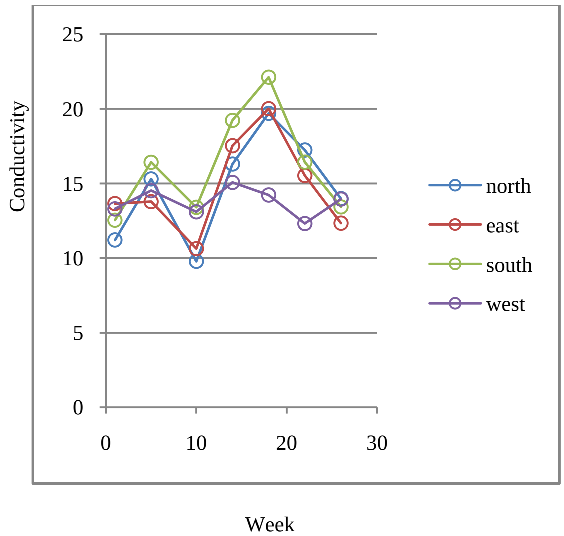

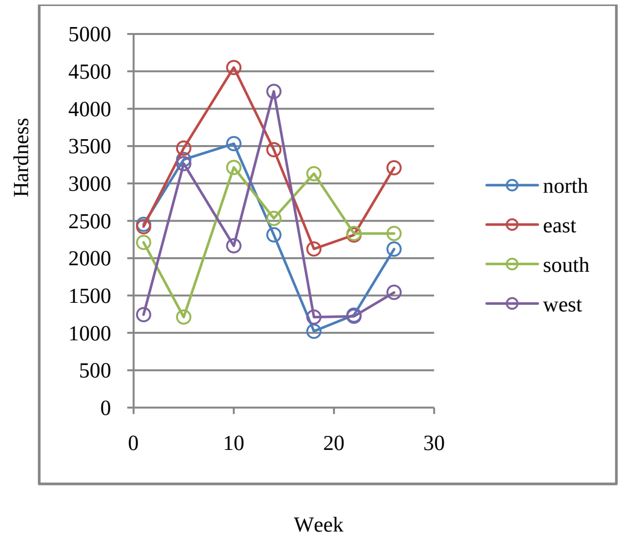

c) Comparison of Data with Who Values

Compared to WHO leachate and surface water in the present study appear to have fairly high conductivity and, to some extent, high Mn, SO_4, NO_3, and Cl contents. The limiting values of BOD and COD according to WHO are 50 and 250.However, in this study it appears large values of BOD and COD for both leachate and surrounding water. On the other hand iron content is relatively low for the surrounding water but iron content in leachate is high than that of WHO limiting value.

VI. Conclusion

The concentration of heavy metals: Cadmium, Iron are found in the leachate and surrounding surface water of Rajbandh landfill site. Total solids, Turbidity, COD and Conductivity, also were well above the permissible levels in surface water of the surrounding area. The results show that the constituent characteristics of Municipal Solid Waste is a major factor influenced on leaching solutions and heavy metal release. Although the leachate is partially treated by roughing filter, it contains huge amount of trace metals and other hazardous compounds which mix with the surrounding surface water and causing heavy pollution of the water and soil of surrounding agricultural lands. By considering all the above facts, it is necessary of designing proper treatment method for the leachate discharging from the landfill site.

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Effect of Casting Temperature on Bond Stress of Reinforced Concrete Structure

By Bappa Kumar Paul, Gopal Chandra Saha, Khokan Kumar Saha & Muhammad Harunur Rashid
Khulna University of Engineering & Technology, Bangladesh

Abstract - This study investigates the influence of mixing and curing temperature on bond behavior of reinforced concrete. The properties examined were compressive strength, splitting tensile strength and bond stress between reinforcing bar and adjacent concrete at three different mixing and curing temperatures (15^{0}C, 30^{0}C and 45^{0}C). For measuring mechanical strength, cylindrical concrete specimens (100 mm dia. x 200 mm height) were prepared. Locally available materials were used to prepare these samples. Bond stress-slip relationship was observed to determine the mechanical properties of the interface between steel re-bars and concrete. Results of compression strength test shows that lower mixing and curing temperature exhibits higher early age strength and comparatively low long period strength in compare to high mixing and curing temperature. Interpretation of bond stress- slip relationship demonstrates that D15DC sample gives 27.4% more bond strength than D45DC sample and P15DC sample gives 38.5% more bond stress than P45DC sample. Average bond stress of deform bars displays 36% more than plain re-bars. This study contributes mainly to explore the bond behavior for different mixing and curing temperature and enlighten the matter that hot environmental condition has great impact bond strength of reinforced concrete structure.

Keywords : bond stress, mixing temperature; curing temperature; reinforced concrete; reinforcing bars.

GJRE Classification : FOR Code : 670904

EFFECT OF CASTING TEMPERATURE ON BOND STRESS OF REINFORCED CONCRETE STRUCTURE

Strictly as per the compliance and regulations of :

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Keywords : bond stress, mixing temperature; curing temperature; reinforced concrete; reinforcing bars.

I. Introduction

Reinforced concrete is a common practice in Civil Engineering. It acts as a composite member when reinforcing bars and concrete residing together. Then they offer most stiffness and durability than others. It is almost depends on their bond behavior. Concrete is placed under many different atmospheric conditions. Sometimes it is placed at hot environment or cold environment. So, temperature has a great impact on reinforced concrete structure.

Concrete this is placed at low temperature develops higher ultimate strength, greater durability and is less subject to thermal cracking [1]. And concrete this is placed at hot temperature, leads to rapid hydration and this results in an increased rate of slump which leads to expedited setting and to a lower long term strength of concrete [2]. The effect of temperature on water demand is mainly brought about by its effect on the rate of cement hydration [3]. When water comes to the cement particle, hydration reaction starts. This hydration reaction is a heat generating reaction. When the ambient temperature is increased with atmosphere then the rate of chemical reaction is increased naturally. So, the ultimate degree of hydration increases with temperature [4]. As a result of the accelerated hydration, initial and final setting times are both reduced with the rise in temperature. A14°C rise in temperature from 10 to 24°C reduced the initial setting time by 8 h while the same rise in temperature from 24 to 38°C reduced the latter by 5 h only [5]. And hot weather conditions more water is required for a given mix to have the same slump, i.e. the same consistency. A 25mm decrease in slump is brought about by a 10°C increase in concrete temperature [6]. The rate of reaction increases with temperature but so does the rate of evaporation from an exposed surface. The ultimate strength of concrete cured at low temperature is generally greater than that of concrete cured at a high temperature, but extremes of temperature generally have a negative effect [7].Concrete cast and cured at high temperature exhibits the expected increased early-age strength, it later-age strength is adversely affected [8,9,10].A better understanding of effect of mixing and curing temperature on reinforced concrete would no doubt aid in the development of concrete structure under various environmental condition especially temperature to predict the bond strength of reinforced concrete structures. The objectives of this study are to investigate the bond strength of reinforced concrete under varying mixing and curing temperature.

II. Experimental Program

The experimental work was carried out to the effect of mixing and curing temperature on bond stress of reinforced concrete. The variable parameters studied and materials and methods involved were as follows:

a) Materials

The experimental program consists of main four types of materials. These are mainly Cement Type I (Ordinary Portland Cement), crushed burned brick, sea bed sand and reinforcing bar.

Author α : Dept. of Civil Engineering, Khulna University of Engineering & Technology, Khulna-9203, Bangladesh.
E-mail : b.bappa89@yahoo.com
Author σ : Dept. of Civil Engineering, Khulna University of Engineering & Technology, Khulna-9203, Bangladesh.
E-mail : gopal.ce07@yahoo.com
Author ρ : Dept. of Farm Power and Machinery, Bangladesh Agricultural University, Mymensingh-2202, Bangladesh.
E-mail : khokan12ag.eng@gmail.com
Author ω : Professor, Dept. of Civil Engineering, Khulna University of Engineering & Technology, Khulna-9203, Bangladesh.
E-mail : hafin02@gmail.com

Table 1 : Chemical composition of ordinary Portland cement materials (Mass %)

Oxide Composition	Ordinary Portland Cement
CaO	62.75
SiO_2	20.83
Al_2O_3	5.29
Fe_2O_3	3.50
MgO	0.52
SO_3	2.44
Na_2O	0.23
Total	95.56
Ignition loss	2.65

i. *Cement*

Cement Type-I, Ordinary Portland Cement was used as a binding materials. The oxide compositions of ordinary Portland cement are summarized in Table (1).

Aggregate:

The properties of fine and coarse aggregates that were used are summarized in Table (2). Sea bed sand was used as a fine aggregate and crushed burned brick was used as a coarse aggregate. The maximum size of coarse aggregate was 19 mm.

Table 2 : Physical properties of coarse and fine Aggregate

Properties	Coarse aggregate (Crushed Burned Brick)	Fine aggregate (Sea Bed Sand)
Maximum aggregate size, (mm)	19.0	2.38
Unit weight(Kg/m^3)	861.02	1555.58
Specific gravity	2.04	2.64
Fineness modulus	-	2.72
Absorption, (%)	18.25	3.19

b) Test Specimens

Six groups of pullout specimens consisting of 100mm (4 in.) x 200mm (8in.) concrete cylinders rebar embedded axisymmetrically were tested. Deform rebar used in three groups and plain rebar used in another three group. Every group contained four specimens. Rebar was casted vertically from the top of the cylinder. Fig.1 shows the pullout test specimen dimension. Type of specimens and rebar, rebar diameter, embedded length, compressive strength and splitting tensile strength are provided in Table (3). For compressive strength test, same size of concrete cylinder was tested for 3 days, 7 days, 28 days and 90 days sample.

c) Concrete Mix Design

The concrete mix for every specimen was based on the mix design. The weight proportion of the concrete of the mixture was 1 (cement) : 1.4 (coarse aggregate) : 2.5 (fine aggregate): 0.5 (water), giving a water to cement ratio (W/C) of 0.5. The concrete was mixed by following the hand mixing method. The concrete mix consisted of 147kg/m^3 water, 295 kg/m^3 cement, 445 kg/m^3 sea bed sand, 500 kg/m^3 burned crushed brick.

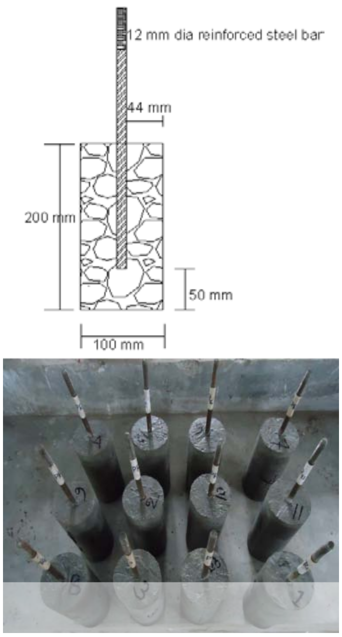

Figure 1 : Dimension of pullout specimen, schematic diagram (left), pictorial diagram(right)

d) Test Method and Loading Instrumentation

Mixing and curing temperature are the main parameter in this research work. Three type of temperature (15°C, 30 °C, and 45 °C) were observed in this study. During sample preparation and curing these temperatures were successively controlled into the laboratory. According to the ASTM C39, 100 mm dia. and height of 200 mm cylindrical concrete specimen were tested by compression strength testing machine for different age of concrete for different mixing and curing temperature. According to the ASTM C496-90, splitting tensile strength test of cylindrical concrete was observed for 28 days for each mixing and curing temperature. And finally bond stress of reinforced concrete was tested according to the illustrated fig. (2).

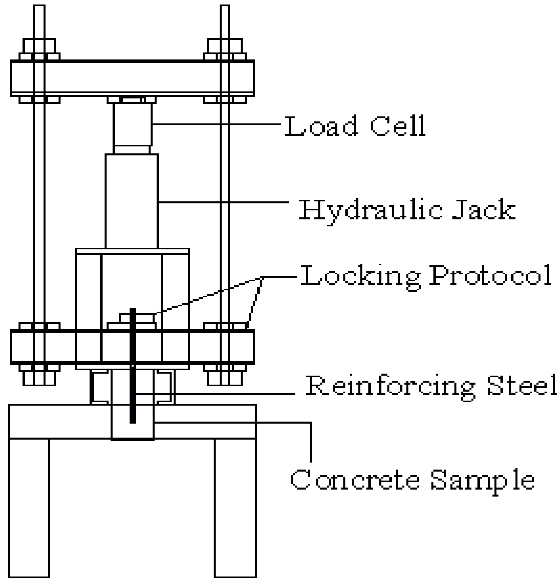

Figure 2 : Test aggangement: compressive strength (left) and pullout test setup frame (right)

III. Results and Discussion

In compressive strength test, measurements of compressive load were taken from compressive strength testing machine. Compressive strength was calculated as compressive loads were divided by cross sectional area of concrete cylinder. Measurements of compressive strength were observed for three mixing and curing temperature such as 15°C, 30°C, 45°C and for several four days (3, 7,28 and 90 days).

The results of compressive strength are plotted in fig. 3 for different temperature for several days. The fig.3 is illustrated that mixing and curing temperature has the direct effect on compressive strength. It shows that at beginning stage of strength gaining process, 45^{0}C casting temperature sample has the higher value of strength than 15^{0}C mixing temperature sample. But 28 days and 90 days strength shows that reverse of 7 days strength value. Due to the high temperature, rate of hydration of cement has increased and initial setting time has decreased.

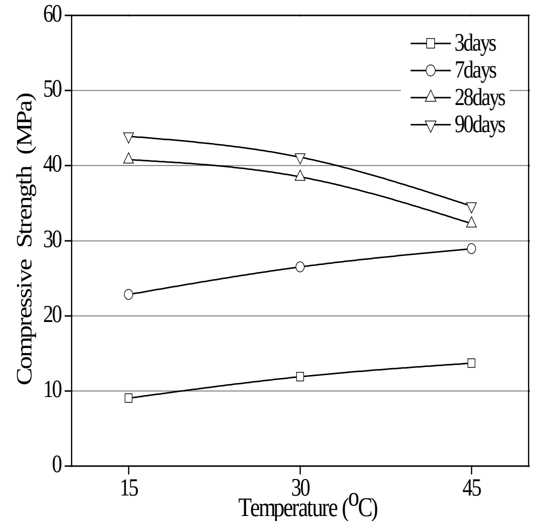

Figure 3 : Effect of mixing and curing temperature on compressive strength of concrete cylinder

Due the low temperature, heat of hydration has been absorbed by the ambient temperature of aggregate. For this hydration rate has decreased and initial setting time has increased. It can conclude considering the initial setting time, for lower setting time 45^{0}C sample gives higher early age strength but long time strength of this sample gives low value and 15^{0}C sample has the reverse strength due to the higher setting value.

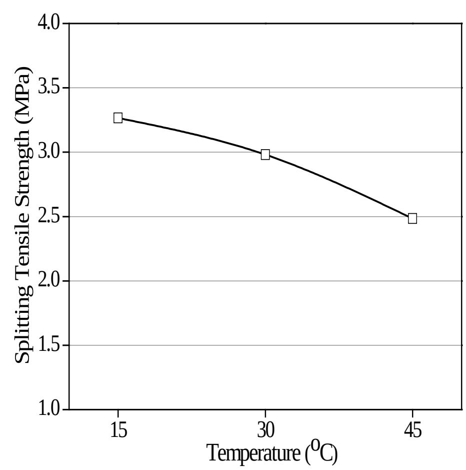

Figure 4 : Effect of mixing and curing temperature on splitting tensile strengthof concrete cylinder

In splitting tesile strength test, the measurements of tensile load were taken from cpmpressive strength testing machine. Splitting tensile strength was calculated as two times of tensile load were divided by surface perimeter of concrete cylinder. Measurements of splitting tensile strength were obseved for different mixing and curing temperature for 28 days. Fig.4 is illustrated that the effect of mixing and curing temperature on splitting tensile strength. It has a small effect on splitting tensile strength. It gives the downward slope of strength from 15^{0}C to 45^{0}C mixing and curing temperature. Lower temperature gives 24% more tensile strength than higher mixing and curing temperature.

Table 4 : Summary of pullout test results of specimens

Specimen	Maximum Load (kN)	Maximum Nominal Steel Stress (MPa)	Failure Slip (mm)	Maximum Bond Stress (MPa)
D15DC	49.35	436.35	0.75	8.59
D30DC	42.98	380.03	1.10	7.48
D45DC	35.78	316.36	0.85	6.23
P15DC	34.01	300.71	0.88	5.92
P30DC	27.46	242.78	0.77	4.78
P45DC	21.37	188.95	0.35	3.72

In Pullout test, measurement of bond load and corresponding slip were taken from the pullout test setup arrangement. Bond stress was calculated as the maximum bond load was divided by the embedded steel surface perimeter. It was observed for deform and plain reinforcing bar as well as different mixing and curing temperature. Table (4) shows that bond stress slip relationship between deform and plain reinforcing bar for different mixing and curing temperature. The pick point of bond stress-slip relationship is indentified as a maximum bond load and corresponding bond slip. The average calculated maximum nominal bond stress, bond load, failure slip and calculated maximum bond stress are shown in Table (4).

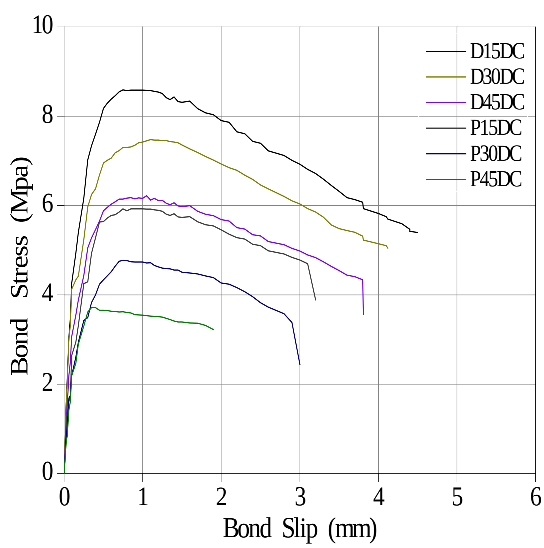

Figure 5 : Effect of mixing and curing temperature on bond stress-slip relationship

The fig. 5 shows that bond stress of deform rebars are always greater than plain bars. Deform rebars show initially more incresing bond nature with respect to slip value than plain rebars. But after maximum bond load these give more slip value than plain rebars.Due to adition and friction defrom rebars give better bond stress than plain rebar. Friction can contribute up to 35%of the ultimate strength governed by the splitting of the concrete cover [11]. For deformed bars, bond stress depends on the mechanical interlocking betwwen ribs and concrete keys. The ultimate bonstrength is reached , shear crack begin to form the concrete between the robs as interlocking forces induce large bearing stress around ribs and large slip occure[12]. It is clear in fig.5 that mixing and curing temperature have a great impact on bond stress. D15DC gives more bond stress and slip value than D30DC and D45DC and P15DC sample gives better bond strength thanP30Dc and P45DC.

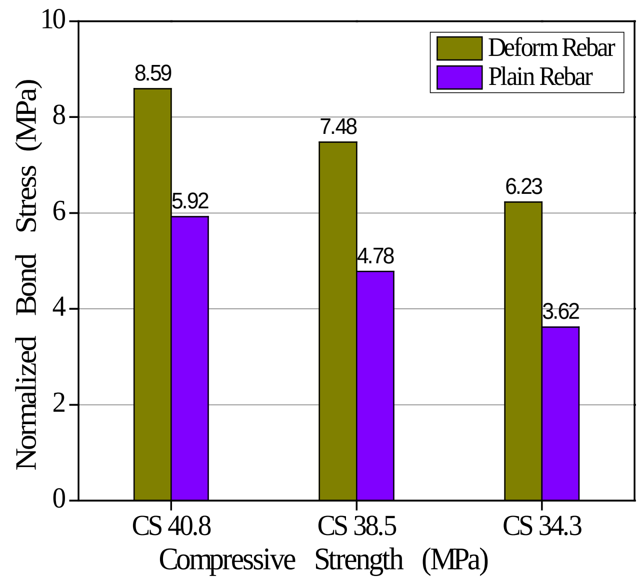

Figure 6 : Variation of normalized bond stress under deform and plain rebars

According to the fig.3, low temperature has great impact on long term strength of reinforced concretea and it illustrates that 15°C mixing and curing temperature sample shows 21% more compressive for 28 days than 45°C sample. Compressive strength is considered to be a significant parameter in bond behavior because the force between steel and concrete is transferred mainly by bearing and bond[13]. It has been found that the bond of high strength concrete is proportional to the compressive strength of concrete[14]. The fig.6 explains the variation of normalized bond stress for deformed and pain reinforcing bars. It shows that D15DC sample gives 27.4% more bond stress than D45DC sample and P15DC sample shows 38.5% more bond stress than P45DC sample. Again average of D15DC, D30DC and D45DC samples gives nearly 36% more bond stress than P15DC,P30Dc and P45DC samples.

IV. Conclusion

Based on the results of this research work, the following conclusions can be drawn with respect to different mixing and curing temperature of concrete.

Lower mixing and curing temperature leads to increase initial setting time of concrete that increase 21% compressive strength for 28 days than higher mixing and curing temperature samples. It increases 27% - 38.5% more bond stress than higher mixing and curing temperature sample. Deform reinforcing bars give 36% more bond stress than plain reinforcing bars due the adhesion, friction and mechanical interlocking of deform rebar's. Finally, lower mixing and curing temperature presents better results than higher mixing and curing temperature.

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Civil Engineering Significant of Peat

By Behzad Kalantari
University of Hormozgan, Iran

Abstract - Peat deposits are the partly decomposed and fragmented remain of plants that have accumulated under water (excessively moistened) and fossilized, and consist of more than 50% organic substances. This type of subsoil foundation has high compressibility and low shear strength when subjected to imposed loads from civil engineering projects. It is essential to distinguish this problematic soil from better quality soils. Visual inspections including colour (dark brown to black) and odour (organic odor) tests can help to recognize peat. Field strength evaluation tests such as FVST and PLT can give good estimates of peat shear strength. Also laboratory tests such as moisture content, organic content and UCS and CBR may be used to evaluate peat physical and mechanical properties as well.

Keywords : peat, organic soils, moisture content, description and classification, physical and mechanical tests.

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Civil Engineering Significant of Peat

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I. Introduction

Hawkes and Webb (1962), define soil as "any loose surface material overlying solid rock". Thus the concept of soil includes not only the detritus of weathered rocks and accumulation of inorganic sediments, rather includes peat as well. According to the Oxford dictionary, the word "peat" is a soft black or brown substance formed from decaying plants (Oxford University Press 1995). In general, peat deposits are the partly decomposed and fragmented remain of plants that have accumulated under water (excessively moistened) and fossilized, and consist of more than 50% organic substances.

These features determine their polyfunctional nature. Botanists and geobotanists study the specific features of bog vegetation on peat soils and the climatic characteristics of the period of the peat accumulation based on the stratigraphy of peat deposits, and they define peat as bogs. Geologists explore peat reserves for industrial purposes and consider peat bogs as peat fields (economic deposits). Hydrologists study the hydrological regime of bogs and determine them as water bodies. Foresters study bogs from the position of improving the quality class of forest stands and call them forest bogs. Soil scientists study peat as agricultural highly fertile soils (Soper and Osbon 1922; Radforth 1969; Babel 1975; Stanek and Worley 1983; Van der Heidjden *et al.* 199; and Inisheva 2006).

To civil engineers peat is an example of extreme type of soft soil, and is called a problematic type of soils, and they characterize peat deposits with the following behaviours (Huat 2004, Kalantari 2010).

Author : University of Hormozgan, Bandar Abbas, Iran.

a) High organic content
b) High natural water content
c) High compressibility
d) Low shear strength

Also organic soils and peat in general show: high liquid limit, low density, relatively low plasticity, and different particle size distribution compared with inorganic soils. It is therefore understandable that any kind of civil engineering construction is usually avoided when facing peat lands. However, peat is found in many countries around the globe. In US, peat is found in 42 states, with a total acreage of 30 million hectares (each hectare is 10,000 m^2). Canada and Russia are the two countries with the largest area of peat, 170 and 150 million hectares respectively. Also, tropical peat cover a total of 30 million hectares of the world land, where two third is located in Southeast Asia (Duraisamy *et al.* 2007).

Due to population increase, and demand for social improvements, and therefore land scarce, there is a strong feeling among civil engineers in general and geotechnical engineers in particular to find ways to strengthen organic soils and peat while keeping the project cost as low as possible. In-order to strengthen peat against imposed loads, it is essential to know its civil engineering characteristics. In the following sections behaviour of this type of foundation subsoils that are more important to civil engineering projects are discussed with more details.

II. Organic Soils and Peat

Any material that contains carbon is called "organic". However, engineers and geologists use more narrow definition when applying the term to soils. An organic soil is one that contains a significant amount of organic material recently derived from plant remains. This implies to be fresh and still in the process of decomposition, and thus retain a distinctive texture, a dark brown to black color, spongy consistency, and an organic odor (Kalantari 2010, Coduto *et al.* 2011). Plant fibres are sometimes visible but in the advanced stages of decomposition, they may not be evident. Organic soils with more than 50% organic content may be considered peat. Peat is usually found as an extremely loose, wet, unconsolidated surface deposit which forms as an integral part of a wetland system, and their civil engineering properties are much worse than those of inorganic soils (Huat 2004, Coduto *et al.* 2010).

III. Distributions of Peat in World

Peat deposits accumulate wherever the conditions are suitable, that is, in areas with excess rainfall, and the ground is poorly drained, irrespective of latitude. Nonetheless, peat deposits tend to be most common in those regions with a comparatively cool, wet climate. Usually water logged poorly drained conditions not only favour the growth of a particular type of vegetation but also help preserve the plant remains (Huat 2004).

Peat is found in many countries around the globe. Canada and Russia are the two countries with a large area of peat, 170 and 150 million hectares respectively (Duraisamy 2008; Alwi 2007; and Huat 2004). Figure 1 shows distribution of peat deposits covering fifteen countries.

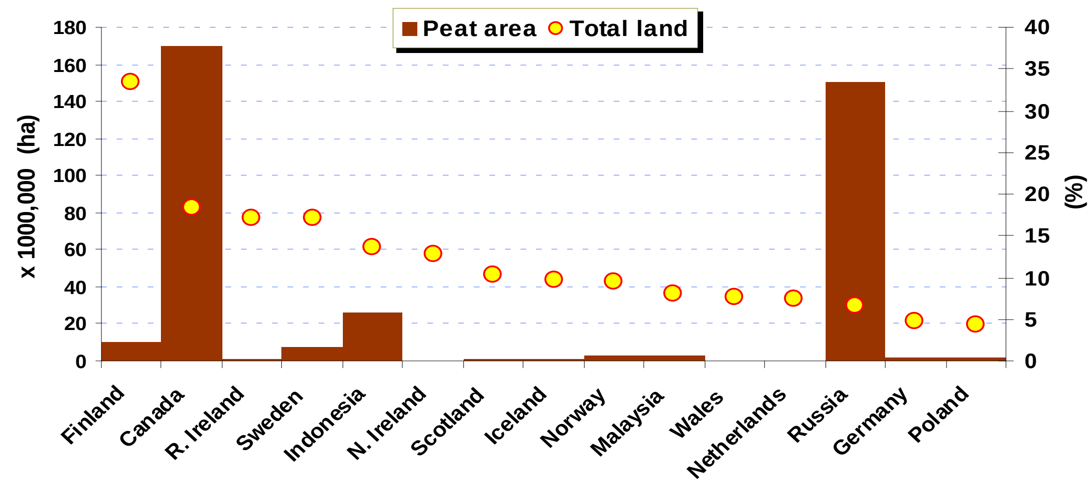

Figure 1 : Percentage of area covered by peat in different countries in rank order (Mesri and Ajlouni 2007; Kalantari 2010; Huat *et al.* 2011)

IV. Description of Peat

For civil engineering purposes, it is essential to describe organic soils or peat. Therefore some essential index properties of these types of subsoil foundations are needed in-order to classify them and find best ways to counter their negative effects on the designed imposed loads. Hobbs (1986) and Edil (1977) suggested the following characteristics to be included for a full description of peat.

a) Colour, and odour
b) Water content
c) Degree of humification
d) Fibre content
e) Liquid limit and plastic limit
f) Principal plant component, namely coarse fibre, fine fibre, amorphous granular material and woody material

V. Classification of Peat

Based on unified soil classification system (USCS), organic soils are recognized as a separate soil entity and have a major division called highly organic soils (pt), which refers to peat, muck and highly organic type of soils. Jarret (1995) gives a classification for organic soils, which can be integrated with the USCS to bridge the gap between peat, and purely inorganic soils that is shown in Table 1.

Table 1 : Classification of organic soils based on their organic content (Jarret 1995)

Basic soil type	Description	Organic content (%)
Clay or silt or sand	Slightly organic	3-20
Organic soil	Organic	20-75
peat	Highly organic	> 75

Another useful tool to classify organic soils or peat is based on their fibre content as well as their humification (decomposition) of the fibres. von Post (1920) proposed a classification system, which is based on a number of critical factors such as degree of humification, botanical composition, water content, content of fine and coarse fibres and woody remnants. There are 10 degrees of humification (H_1 to H_{10}, with H_1 being the least and H_{10} being the most decomposed) in the von Post classification system that are determined based on the appearance of peat water that is extruded when the soil is squeezed in the hand. A more summarized version of von Post classification guideline that is also in part proposed by Malaysian soil classification systems for engineering purposes is shown on Table 2.

Table 2 : Classification of peat on the basis of degree of decomposition (Karlson and Hansbo 1981; Jarret 1995)

Designation	Group	Description
Fibrous peat	H_1-H_4	Low degree of decomposition. Fibrous structure. Easily recognized plant.
Pseudo-fibrous peat	H_5-H_7	Intermediate degree of decomposition. Recognizable plant structure.
Amorphous peat	H_8-H_{10}	High degree of decomposition. No visible plant structure. Mushy consistency.

The U.S department of agriculture (USDA) classifies peat in three-point scale with respect to fibre content that is determined by ASTM D 1997 test and is the result of decomposition process of peat materials. This type of classification is shown in Table 3.

Table 3 : USDA classification of peat (Huat 2004)

Type of peat	Fiber content	von Post Scale
Fibric peat	Over 66%	H_4 or less
Hemic peat	33-66%	H_5 or H_6
Sapric Peat	Less than 33%	H_7 **or more**

Also American association of state and highway transportation officials (AASHTO), as well as federal aviation administration (FAA) among soils from A-1 to A-8 classify peat as A-8.

VI. Engineering Properties of Peat

In order to identify major components of any type of soils and determining soil engineering properties, it is essential to conduct various types of tests. These tests may be divided to physical and mechanical tests. Physical tests begin with visual inspection of the soil, as far as soil's appearance, colour, possible odour, and plasticity are concerned. These methods, however, represent only the first step in adequate description of soil material. They must be supplemented by other procedures leading to quantitative results that may be related to the physical properties with which the engineer is directly concerned (Peck *et al.* 1974). After visual inspection of soil, tests that usually follow are index property tests and mechanical property tests. Organic soils and peat are not exceptions and the same types of tests are to be carried out on them as well.

Some of the most useful index property tests for civil engineers for organic soils and peat include:

a) Water content
b) Loss on ignition and organic content
c) Fibre content
d) Grain size distribution
e) Density and Specific Gravity
f) Atterberg Limits

Also the most useful mechanical tests (laboratory and field) for organic soils and peat are:

a) California bearing ratio (CBR)
b) Unconfined compressive strength (UCS)
c) Triaxial
d) Permeability (falling head)
e) Consolidation
f) Compaction (unusual but possible)
g) Field strength evaluation tests
   i. Vane shear test
   ii. Plate load test

Other tests such as pH (for degree of acidity), scanning electron microscopy or SEM (for microstructure analysis) and energy dispersing x-ray analysis or EDXA (for chemical characterization analysis) may also be used to complete the testing procedure for peat as well.

VII. Conclusions

Peat is one of the most problematic subsoil foundations that engineers are faced when civil engineering projects are concerned. This type of soil has low shear strength, and high compressibility when subjected to imposed loads. It is essential to distinguish this problematic soil from better quality soils. Visual inspections including colour (dark brown to black) and odour (organic odor) tests can help to recognize peat at field. Peat usually has unusual high moisture content (more than 100%) compared with inorganic soils. This type of soil may be changed (more decomposed) in shape through time. Peat may be classified as three types namely; fibric, hemic and sapric with sapric being the most decomposed compared with fibric that is the most fibrous and less decomposed. Field tests such as vane shear test (VST) and plate load test (PLT) can be carried out to check shear strength of peat. Also a few laboratory tests may provide some important parameters which can help the civil engineers to analyze best possible methods to combat this difficult soil. These tests include; water content, organic content, unconfined compressive strength (UCS), and California bearing ratio (CBR). Also, depth of existing peat, type of project, and cost-benefit ratio are considerable factors to be considered when dealing with peat deposit as well.

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4. Manuscript's Category,

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- Separating a table/chart or figure - impound each figure/table to a single page
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In every sections of your document

· Use standard writing style including articles ("a", "the," etc.)

· Keep on paying attention on the research topic of the paper

· Use paragraphs to split each significant point (excluding for the abstract)

· Align the primary line of each section

· Present your points in sound order

· Use present tense to report well accepted

· Use past tense to describe specific results

· Shun familiar wording, don't address the reviewer directly, and don't use slang, slang language, or superlatives

· Shun use of extra pictures - include only those figures essential to presenting results

Title Page:

Choose a revealing title. It should be short. It should not have non-standard acronyms or abbreviations. It should not exceed two printed lines. It should include the name(s) and address (es) of all authors.

Abstract:

The summary should be two hundred words or less. It should briefly and clearly explain the key findings reported in the manuscript--must have precise statistics. It should not have abnormal acronyms or abbreviations. It should be logical in itself. Shun citing references at this point.

An abstract is a brief distinct paragraph summary of finished work or work in development. In a minute or less a reviewer can be taught the foundation behind the study, common approach to the problem, relevant results, and significant conclusions or new questions.

Write your summary when your paper is completed because how can you write the summary of anything which is not yet written? Wealth of terminology is very essential in abstract. Yet, use comprehensive sentences and do not let go readability for briefness. You can maintain it succinct by phrasing sentences so that they provide more than lone rationale. The author can at this moment go straight to shortening the outcome. Sum up the study, with the subsequent elements in any summary. Try to maintain the initial two items to no more than one ruling each.

- Reason of the study - theory, overall issue, purpose
- Fundamental goal
- To the point depiction of the research
- Consequences, including definite statistics - if the consequences are quantitative in nature, account quantitative data; results of any numerical analysis should be reported
- Significant conclusions or questions that track from the research(es)

Approach:

- Single section, and succinct
- As a outline of job done, it is always written in past tense
- A conceptual should situate on its own, and not submit to any other part of the paper such as a form or table
- Center on shortening results - bound background information to a verdict or two, if completely necessary
- What you account in an conceptual must be regular with what you reported in the manuscript
- Exact spelling, clearness of sentences and phrases, and appropriate reporting of quantities (proper units, important statistics) are just as significant in an abstract as they are anywhere else

Introduction:

The **Introduction** should "introduce" the manuscript. The reviewer should be presented with sufficient background information to be capable to comprehend and calculate the purpose of your study without having to submit to other works. The basis for the study should be offered. Give most important references but shun difficult to make a comprehensive appraisal of the topic. In the introduction, describe the problem visibly. If the problem is not acknowledged in a logical, reasonable way, the reviewer will have no attention in your result. Speak in common terms about techniques used to explain the problem, if needed, but do not present any particulars about the protocols here. Following approach can create a valuable beginning:

- Explain the value (significance) of the study
- Shield the model - why did you employ this particular system or method? What is its compensation? You strength remark on its appropriateness from a abstract point of vision as well as point out sensible reasons for using it.
- Present a justification. Status your particular theory (es) or aim(s), and describe the logic that led you to choose them.
- Very for a short time explain the tentative propose and how it skilled the declared objectives.

Approach:

- Use past tense except for when referring to recognized facts. After all, the manuscript will be submitted after the entire job is done.
- Sort out your thoughts; manufacture one key point with every section. If you make the four points listed above, you will need a least of four paragraphs.

- Present surroundings information only as desirable in order hold up a situation. The reviewer does not desire to read the whole thing you know about a topic.
- Shape the theory/purpose specifically - do not take a broad view.
- As always, give awareness to spelling, simplicity and correctness of sentences and phrases.

Procedures (Methods and Materials):

This part is supposed to be the easiest to carve if you have good skills. A sound written Procedures segment allows a capable scientist to replacement your results. Present precise information about your supplies. The suppliers and clarity of reagents can be helpful bits of information. Present methods in sequential order but linked methodologies can be grouped as a segment. Be concise when relating the protocols. Attempt for the least amount of information that would permit another capable scientist to spare your outcome but be cautious that vital information is integrated. The use of subheadings is suggested and ought to be synchronized with the results section. When a technique is used that has been well described in another object, mention the specific item describing a way but draw the basic principle while stating the situation. The purpose is to text all particular resources and broad procedures, so that another person may use some or all of the methods in one more study or referee the scientific value of your work. It is not to be a step by step report of the whole thing you did, nor is a methods section a set of orders.

Materials:

- Explain materials individually only if the study is so complex that it saves liberty this way.
- Embrace particular materials, and any tools or provisions that are not frequently found in laboratories.
- Do not take in frequently found.
- If use of a definite type of tools.
- Materials may be reported in a part section or else they may be recognized along with your measures.

Methods:

- Report the method (not particulars of each process that engaged the same methodology)
- Describe the method entirely
- To be succinct, present methods under headings dedicated to specific dealings or groups of measures
- Simplify - details how procedures were completed not how they were exclusively performed on a particular day.
- If well known procedures were used, account the procedure by name, possibly with reference, and that's all.

Approach:

- It is embarrassed or not possible to use vigorous voice when documenting methods with no using first person, which would focus the reviewer's interest on the researcher rather than the job. As a result when script up the methods most authors use third person passive voice.
- Use standard style in this and in every other part of the paper - avoid familiar lists, and use full sentences.

What to keep away from

- Resources and methods are not a set of information.
- Skip all descriptive information and surroundings - save it for the argument.
- Leave out information that is immaterial to a third party.

Results:

The principle of a results segment is to present and demonstrate your conclusion. Create this part a entirely objective details of the outcome, and save all understanding for the discussion.

The page length of this segment is set by the sum and types of data to be reported. Carry on to be to the point, by means of statistics and tables, if suitable, to present consequences most efficiently.You must obviously differentiate material that would usually be incorporated in a study editorial from any unprocessed data or additional appendix matter that would not be available. In fact, such matter should not be submitted at all except requested by the instructor.

Content

- Sum up your conclusion in text and demonstrate them, if suitable, with figures and tables.
- In manuscript, explain each of your consequences, point the reader to remarks that are most appropriate.
- Present a background, such as by describing the question that was addressed by creation an exacting study.
- Explain results of control experiments and comprise remarks that are not accessible in a prescribed figure or table, if appropriate.
- Examine your data, then prepare the analyzed (transformed) data in the form of a figure (graph), table, or in manuscript form.

What to stay away from

- Do not discuss or infer your outcome, report surroundings information, or try to explain anything.
- Not at all, take in raw data or intermediate calculations in a research manuscript.
- Do not present the similar data more than once.
- Manuscript should complement any figures or tables, not duplicate the identical information.
- Never confuse figures with tables - there is a difference.

Approach

- As forever, use past tense when you submit to your results, and put the whole thing in a reasonable order.
- Put figures and tables, appropriately numbered, in order at the end of the report
- If you desire, you may place your figures and tables properly within the text of your results part.

Figures and tables

- If you put figures and tables at the end of the details, make certain that they are visibly distinguished from any attach appendix materials, such as raw facts
- Despite of position, each figure must be numbered one after the other and complete with subtitle
- In spite of position, each table must be titled, numbered one after the other and complete with heading
- All figure and table must be adequately complete that it could situate on its own, divide from text

Discussion:

The Discussion is expected the trickiest segment to write and describe. A lot of papers submitted for journal are discarded based on problems with the Discussion. There is no head of state for how long a argument should be. Position your understanding of the outcome visibly to lead the reviewer through your conclusions, and then finish the paper with a summing up of the implication of the study. The purpose here is to offer an understanding of your results and hold up for all of your conclusions, using facts from your research and generally accepted information, if suitable. The implication of result should be visibly described. Infer your data in the conversation in suitable depth. This means that when you clarify an observable fact you must explain mechanisms that may account for the observation. If your results vary from your prospect, make clear why that may have happened. If your results agree, then explain the theory that the proof supported. It is never suitable to just state that the data approved with prospect, and let it drop at that.

- Make a decision if each premise is supported, discarded, or if you cannot make a conclusion with assurance. Do not just dismiss a study or part of a study as "uncertain."
- Research papers are not acknowledged if the work is imperfect. Draw what conclusions you can based upon the results that you have, and take care of the study as a finished work
- You may propose future guidelines, such as how the experiment might be personalized to accomplish a new idea.
- Give details all of your remarks as much as possible, focus on mechanisms.
- Make a decision if the tentative design sufficiently addressed the theory, and whether or not it was correctly restricted.
- Try to present substitute explanations if sensible alternatives be present.
- One research will not counter an overall question, so maintain the large picture in mind, where do you go next? The best studies unlock new avenues of study. What questions remain?
- Recommendations for detailed papers will offer supplementary suggestions.

Approach:

- When you refer to information, differentiate data generated by your own studies from available information
- Submit to work done by specific persons (including you) in past tense.
- Submit to generally acknowledged facts and main beliefs in present tense.

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Introduction	Containing all background details with clear goal and appropriate details, flow specification, no grammar and spelling mistake, well organized sentence and paragraph, reference cited	Unclear and confusing data, appropriate format, grammar and spelling errors with unorganized matter	Out of place depth and content, hazy format
Methods and Procedures	Clear and to the point with well arranged paragraph, precision and accuracy of facts and figures, well organized subheads	Difficult to comprehend with embarrassed text, too much explanation but completed	Incorrect and unorganized structure with hazy meaning
Result	Well organized, Clear and specific, Correct units with precision, correct data, well structuring of paragraph, no grammar and spelling mistake	Complete and embarrassed text, difficult to comprehend	Irregular format with wrong facts and figures
Discussion	Well organized, meaningful specification, sound conclusion, logical and concise explanation, highly structured paragraph reference cited	Wordy, unclear conclusion, spurious	Conclusion is not cited, unorganized, difficult to comprehend
References	Complete and correct format, well organized	Beside the point, Incomplete	Wrong format and structuring

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