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DISCOVERING THOUGHTS AND INVENTING FUTURE

Highlights

- Concrete Beams Reinforced
- Land use/cover classification
- Investigations on Microsilica
- Self Compacting Concrete

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Estimation of Production rates for Formwork Installation using Fuzzy Expert Systems

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Abstract - Expert Systems have been used to solve complex problems efficiently if the information available is in descriptive form rather than numbers. The study has aimed to use Fuzzy expert systems to estimate the labor production rates. Production rate values of formwork installation of beam have been measured from the project sites and factors influencing the production rates have been recorded on scale in descriptive form. Fuzzy expert system developed in this study has been compared with the previous Fuzzy expert systems used for estimating production rates. Mean Square Error of the previous and new models has been calculated and shows that proposed model gives high linguistic and numerical accuracies. Hence, the Fuzzy expert system developed in this study can be used reliably for estimating labor productivity by the construction Industry.

Keywords : Artificial intelligence, Fuzzy Expert Systems, Production Rates, Influencing Factors.

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ESTIMATION OF PRODUCTION RATES FOR FORMWORK INSTALLATION USING FUZZY EXPERT SYSTEMS

Strictly as per the compliance and regulations of:

Estimation of Production rates for Formwork Installation using Fuzzy Expert Systems

Arazi Bin Idrus [α], Sana Muqeem [Ω], Yap Keem [β], Mohd Faris Khamidi [ψ], Mohd Saiful Zakaria [¥]

Abstract - Expert Systems have been used to solve complex problems efficiently if the information available is in descriptive form rather than numbers. The study has aimed to use Fuzzy expert systems to estimate the labor production rates. Production rate values of formwork installation of beam have been measured from the project sites and factors influencing the production rates have been recorded on scale in descriptive form. Fuzzy expert system developed in this study has been compared with the previous Fuzzy expert systems used for estimating production rates. Mean Square Error of the previous and new models has been calculated and shows that proposed model gives high linguistic and numerical accuracies. Hence, the Fuzzy expert system developed in this study can be used reliably for estimating labor productivity by the construction Industry.

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I. Introduction

Construction productivity is the main indicator of the performance of construction industry. It is constantly declining over a decade due to the lack of standard productivity measurement system and negligence of various factors influencing labor productivity. Different techniques have been developed to estimate construction productivity. These includes Factor Model by Thomas and Yiakoumis (1987) for predicting productivity using factors, Expectancy model by Maloney and Fillen (1985) for predicting performance of workers to estimate productivity, Action Response model by Halligan (1994) to evaluate losses in construction productivity, Herbsman and Ellis (1990) have developed Statistical model to identify the affects of factors on productivity, An Expert Simulation model developed by Boussaabaine and Duff (1996) to identify the combine effects of the factors on productivity. These modelling techniques have been developed for specific conditions and their implementation was mostly restricted with the information available (Oduba 2002). In addition, in order to solve complex non-linear problems these techniques have several limitations.

Therefore, the objective of this study is to use Artificial Intelligence technique for the estimation of labor productivity. It has been identified that Artificial Intelligence techniques have been using to solve the problems in construction management research through decades. These techniques have strong and dynamic learning mechanism with effective recognition capabilities to solve complex non-linear problems. Among the different Artificial Intelligence techniques the most commonly used in construction management is Fuzzy Expert System.

II. Fuzzy Expert System

Fuzzy expert systems relates input variable with output variables in the form of linguistic values based on fuzzy if-then rules. Membership functions of input variables represented by fuzzy antecedents of if-then rules whereas the membership functions of the output variables represents fuzzy consequents of if-then rules (Aminah *et al.* 2005). Reasoning of fuzzy expert systems is based on fuzzy inference mechanisms. The basic structure of fuzzy inference mechanism consists of three components: *rule base*; which contain selection of rules, *database*; which defines membership function used in fuzzy rules and *reasoning mechanism*; which perform inference procedure (Jang *et al.* 1997).

There are few applications of fuzzy expert systems in the field of construction management. For estimating construction labor production rates, fuzzy expert system has been used by Hongwei (1999) and Oduba (2002). Hongwei (1999) has estimated labour productivity using fuzzy set theory. Method of using fuzzy set theory has been explored for estimating labor production rate for concrete wall formwork. Different factors influencing labor productivity of concrete wall formwork have been identified and fuzzy logic estimation model has been developed. Fuzzy inference engine, fuzzification module and defuzzification module have been prepared and productivity has been predicted as a linguistic assertion. However, the data used in this research are based on historical records which are limited and inconsistent therefore the accuracy of the results of fuzzy expert system developed can be questioned.

Oduba (2002) has also predicted labor productivity using fuzzy expert systems. Productivities for industrial rig pipe and weld pipe activities has been predicted after identifying the various influencing factors

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on these activities. To identify the influence of these factors membership functions have been developed. Relationship between the productivities with influencing factors has been predicted by developing fuzzy rule-base in fuzzy expert systems. Despite the fuzzy expert systems resulted in high linguistic accuracy but the use of large number of input factors has caused exponential growth of rules and made it complicated to understand.

Therefore, this study has aimed to use fuzzy expert system for estimating construction labor production rates by collecting the data from direct observation of project sites and develop fuzzy expert system by using selected factors that significantly influence the productivity of labor.

III. Factors Influencing Labor Productivity

Through the literature review, total seventeen factors that influenced the labor production rates at site have been identified.

Table 1 : Importance Index Parameters

Influencing Factors	Importance Index	Ranking
Availability of material & equipment	66	**1**
No. of workers	61	**2**
Weather	60	**3**
Site Conditions	59	**4**
Location of the project	58	**5**
Motivation and incentive	54	6
Labor work load	51	7
Absenteeism	40	8
Rework	37	9
Delays in material delivery to site	36	10
Inspection delays	35	11
Labor disruption	33	12
Poor Scheduling and Coordination	32	13
Disruption of Power/Water Supplies	30	14
Communication Problems	31	15
Skill level of labor	29	16
Buildability	28	17

Table 2 : Influencing factors Parameters

Factors/ Likert Scale	1	2	3	4	5
	Low Severe	**Slightly low Severe**	**Moderate**	**Slightly high severe**	**Highly severe**
Weather (F1)	Very Pleasant	Pleasant	Moderate/sunny	Hot weather	Very hot weather
Availability of material and Equipment (F2)	Completely available	Adequately available	Inadequately available	Shortage of material	Completely unavailable
Location of project (F3)	Accessible/Urban area	Sub-urban area	Rural-urban	Sub-rural area	Inaccessible/ Rural area
Site conditions (F4)	Very clear	clear	Slightly congested	congested	Very congested
Number of workers (F5)	Completely available	Adequately available	Inadequate Availability	Shortage of workers	Completely unavailable

Questionnaire survey has been carried out to rank each factor according to their importance by using Likert scale of 1 to 5 where 1 means not important and 5 means extremely important. Factors are ranked as highly significant by calculating the Importance Index by using the formula;

$$\text{Importance Index} = \frac{5n_1 + 4n_2 + 3n_3 + 2n_4 + n_5}{5(n_{1+}n_2 + n_3 + n_4 + n_5)}$$

Top five factors have been selected which are weather, availability of material and equipment, project location, site conditions and number of workers as shown in Table 1. These factors have been selected to record at sites on the Likert scale of 1 to 5 where 1 means low severe and 5 means high severe as shown in Table 2.

IV. Production Rates

Various ongoing concrete building projects have been identified in different parts of Malaysia that includes Ipoh, Kuala Lumpur, Grik, Subang, Selangor, Melaka. Direct observation method has been used to measure the production rates and influencing factors at site. Production rates of installation of formwork of beam have been selected to measure. Simultaneously, five factors selected earlier have also been recorded. Total seven numbers of projects have been observed. Weekly site visits had been done and are the production rates are recorded at specific interval of times. Eighty four (84) numbers of observations have been collected. Stop watch has been used to calculate duration of activities at specific time interval.

V. Model Development

Fuzzy expert systems developed previously for predicting labor productivity have been considered. Two fuzzy logic models that have been developed by Hongwei (1999) and Oduba (2002) for estimating labor productivity. New Fuzzy expert system has also been developed by considering new parameters.

a) Model 1(Hongwei 1999)

Same parameters of fuzzy expert system have been considered as developed by Hongwei in 1999. For input variables and output variable three membership functions have been used with five linguistic terms. The shape of the membership function used for input variable and output variable is triangular. Fuzzy if-then rules have been developed through logical reasoning. Mamdani inference system has been considered with min-max composition where implication and aggregation methods used are minimum and maximum. Mean of Maximum (MOM) method is used for defuzzifucation.

b) Model 2 (Oduba 2002)

Similarly the parameters of the fuzzy expert system developed by Oduba in 2002 have been considered. Three membership functions have been used for input and output variables with three linguistic terms. The shape of the membership function used for input variable and output variable is triangular. Fuzzy if-then rules have been developed through logical reasoning. Mamdani inference system has been considered with min-max composition and implication and aggregation methods used are minimum and maximum. Defuzzification method used is centriod.

c) New Model

A new fuzzy expert system has been developed with new parameters. Five membership functions have been used for input and output variables with five linguistic terms. The shape of the membership function used for input variable and output variable is gaussian. Fuzzy if-then rules have been developed through logical reasoning. Sugeno inference system has been considered with min-max composition where implication and aggregation methods used are minimum and maximum. Defuzzification method used is weight age average.

VI. Performance of Models

Data collected in this research have been used in the two previously developed and newly developed Fuzzy Expert systems. Performance of the systems has been evaluated by calculating Mean Square Error (MSE), numerical and linguistic accuracies.

As shown in Table 3, MSE calculated from New Model is lower than Model 1 and Model 2. Thus, indicating that New Model has estimated the production rates with least range of errors.

Numerical accuracies for Model 1 and Model 2 have been calculated. Percentage error of each data points have been measured and the numerical match is considered if error is less than 33% as three membership functions have been used representing 33% of the data. Numerical accuracy is obtained by calculating percentage of numerical matches over total number of data points (Oduba 2002). Similarly, if the defuzzified output matches with the linguistic term of actual output then it is considered linguistic match. Numerical accuracies calculated for Model 1 and Model 2 are equal to 44% and 71%. Model 2 resulted in high numerical accuracy as compare to Model 1. The linguistic accuracies of Model 1 and Model 2 are 21% and 50% which are significantly lower.

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Table 3 : Fuzzy Expert Systems Results

Fuzzy Expert Systems	Formwork installation of Beam		
	MSE	Numerical Accuracy	Linguistic Accuracy
MODEL 1	0.000390	44%	21%
MODEL 2	0.1645	71%	50%
NEW MODEL	0.000067	75%	53%

For New Model, numerical accuracies have been calculated. However, percentage error less than 20% is considered as numerical match as the five linguistic terms have been used where each membership function representing 20% of data. Table 3 shows that the numerical and linguistic accuracies calculated from New Model is 75% and 53% which are higher as compare to Model 1 and Model 2. Thus for this study, changing the shape of membership function from triangular to Gaussian, linguistic terms from three to five, fuzzy inference system from Mamdani to Sugeno and Defuzzification method from centriod and Mean of Maximum to weight age average; gives more reliable and accurate results with high numerical and linguistic accuracies.

VII. Conclusion and Recommendations

Construction labor production rates of formwork installation of beams have been estimated by using influencing factors which were in descriptive forms. This study has achieved its objective by estimating reliable production rates for formwork installation by using Fuzzy Expert System with least Mean Square Error and with high numerical and linguistic accuracies. However, for more accurate results the study can be conducted by increasing more data. Also, sensitivity analysis is needed to identify the influence of each factor on the production rates.

Hence, this study has provided a framework for developing more accurate estimation technique using fuzzy expert system in the field of construction management.

Acknowledgement

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References Références Referencias

1. Aminah Robinson Fayek and Ayodele Oduba. (2005), Predicting Industrial Labor Productivity using Fuzzy expert system. *Journal of Construction Engineering and Management.* Vol. 131, No. 8, August 1, 2005. I SSN 0733-9364/2005/8-938–941/$25.00.
2. Ayodele Olugbenga Oduba. (2002), Predicting Industrial construction Productivity using Fuzzy Expert Systems. 2002 . University of Alberta.
3. Boussabiane, A.H. and Duff, A.R. (1996), An Expert Simulation System for Construction Productivity Forecasting. *Building Research and Information.* 1996. 24(5): 279-286.Engineering and Management
4. Halligan David W., Demsetz, Laura A. Brown, James D. (1994), Action Response Model and Loss of Productivity in Construction. *Journal of Construction Engineering and Management*. 1994. 120(1): 47:64.
5. Herbsman, Z. and Ellis, R. (1990), Research of factors Influencing Construction Productivity. *Construction Management and Economics.* 1990, 8(1), 49-61.
6. Hongwei Mao. (1999), Estimating labor Productivity using Fuzzy Expert Systems. *Construction Engineering Management.* University of Alberta.
7. Maloney, W.F. and Fillen, J.M. (1985), Valence of Satisfaction and Job Outcomes. *Journals of Construction Engineering and Management*. ASCE,111(1):53:73.
8. Thomas H.R and Yiakoumis I. (1987), Factor Model of Construction Productivity. *Journal of Construction Engineering and Management.* 1987. 113(4), 623-9.

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Land use/cover classification- An introduction review and comparison

By Dr. Swapan Kumar Deb, Rajiv Kumar Nathr
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Abstract - Accurate and reliable information about land use and land cover is essential for change detection and monitoring of the specified area. It is also useful in the updating the geographical information about the area. Over the past decade, a significant amount of research has been conducted concerning the application of different classifier and image fusion technique in this area. In this paper, introductions to the land use and land cover classification techniques are given and the results from a number of different techniques are compared. It has been found that, in general fusion technique perform better than either conventional classifier or supervised/unsupervised classification.

Keywords : Land Cover. Land, Fusion, Multiresolution, supervised, unsupervised.

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LAND USECOVER CLASSIFICATION- AN INTRODUCTION REVIEW AND COMPARISON

Strictly as per the compliance and regulations of:

Land use/cover classification- An introduction review and comparison

Dr. Swapan Kumar Deb [α], Rajiv Kumar Nathr [Ω]

Abstract - Accurate and reliable information about land use and land cover is essential for change detection and monitoring of the specified area. It is also useful in the updating the geographical information about the area. Over the past decade, a significant amount of research has been conducted concerning the application of different classifier and image fusion technique in this area. In this paper, introductions to the land use and land cover classification techniques are given and the results from a number of different techniques are compared. It has been found that, in general fusion technique perform better than either conventional classifier or supervised/unsupervised classification.

Keywords : Land Cover. Land, Fusion, Multiresolution, supervised, unsupervised.

I. Introduction

Land-Cover/Land-use, being the new concept developing with the remote sensing technology, has become a crucial item of basic tasks in order to carry through a series of important works, such as the prediction of land-use change, prevention of nature disaster, management and plan land use, protection of environment, etc,. With the more thorough development of remote sensing technology and Geo-Analysis model, using remotely sensed data to monitor the status and dynamical change of land-cover/land-use is become the one of the one of the most rapid, credible and effectual method. Land-cover and Land-use are two different concepts in its intrinsic signification .Land-cover emphasize particularly on its nature properties and it is the synthetically reflection of various elements in global surface covered with natural body or manual construction. Using remote sensing classification method, whatever used or non-used covering object in surface can be separated. However, Land-use, emphasizing more on land's social properties, is the output of reconstruction activities that human adopts a serial of biologic, technologic measure to manage and regulate the land chronically and periodically according to determinate economic and social purpose. Thus, land-use is a process of turning natural ecosystem into social ecosystem, and the process is a complicated procedure by the synthetic effect from nature, economy and society. The manner, degree, structure, area distributing and benefit of land-use are not only affected by natural condition nut also restricted by diversified natural, economic and technologic condition, and in sometimes among all factors the social production form is determinant Land-use is the most direct and leading driving factor to the land-cover change. In carrying out research and application of the land-covert and land-use remote sensing investigation, the uniform classification system is usually built up by combining the two concepts under one system, which is called Remote Sensing Land-Cover/Land-Use classification system. There are various methods that have been developed to perform the Land-Cover/Land Classification particularly for multispectral and panchromatic imagery.

Satellite images are constituted by a set of measures of electromagnetic radiation. Each individual measure corresponds to an area unit (pixel) and a certain interval of wave-length (channel). Many projects have been carried out in the last years by national or international organizations as well as by private companies for making land cover maps or databases through photo-interpretation or automatic classification of satellite data. The most extensive use of remote sensing data is in the construction of land cover maps. In recent years, with the spread of Geographic Information Systems (GIS), databases rather than maps have been generally produced. Sometimes, some classes of adopted legends can be considered land use classes rather than land cover ones; therefore, many maps based on photo-interpretation of remote sensing data are called land cover/land use maps. CORINE land cover [1] is a relevant example of a land cover database created mainly on the basis of remote sensing data.

II. Land Use/Cover Classification

a) By Fusion

The power of data fusion based on statistics of thermal infrared images at 1 km resolution, resolution, with visible and near infrared images at 20-m resolution that better match the urban scale. The results demonstrate the capabilities of remote sensing to derive some components of the urban energy balance, and to monitor their spatial and temporal variability [2]. To extract rural human settlement, different agricultural cultivation types, urban and built up area with different construction density combination of optical and multi-temporal SAR data is quite simple compare to use anyone of them alone[3].

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Definiens eCognition was used to identify land cover types by examination of panchromatic data from different sources (SPOT and KOMPSAT-1), recorded at different spatial resolutions. The geospatial techniques is used for combining multi-concept image datasets, geospatial themes and population census data to study various surface features in the environs of Lahore district, the dynamics of urban expansion with reference to population growth, and analyze different population aspects with reference to the spatial distribution of urban and rural administrative units within the district. And also gives the information that which dataset have been found appropriate and effective for classification of land use/ land cover features [4]. EOS-MISR, Landsat-ETM+ and RadarSat-SAR are fused together to find out the effect of land cover and land use to carbon cycle and climate change modelling [5]. The Gaussian mixture classification and the multi-scale classification algorithm (SMAP) were used with different combination consisting of the SPOT image and the airborne multi-polarized SAR data (EMISAR), [6]. An ASTER sensor imagery, which was converted into top-of-atmosphere reflectance (TOA), was used to classify the land use/cover types, according to Co-ordination of Information on the Environment (CORINE) land cover nomenclature, for an area representing the heterogonous characteristics of eastern Mediterranean regions in Kahramanmaras, Turkey [7]. The Optical and SAR sensor data are co-registered for data fusion and classification process of five classes: crops, water, built-up, forest and grass Missouri [8]. The utility of radar is to accurately locate areas of natural vegetation, scattered agricultural, and settlements. Radar data were able to accurately map these features with approximately the same accuracy as TM [9]. Landsat TM and microwave data (contemporaneous image of the new radar sensor SIR-C/X-SAR) were combined through calculation of the principal components of the multidimensional data sets and a final classification was carried out and compared with the classifications obtained from optical and radar recordings separately [10]. The land use transformations are a result of the interaction of the biophysical drivers and human drivers. It applies the concept of the presence of an agent as the decision maker based on the information available to it at a particular point in time and space, in simulation the land use/cover changes [11].

Microwave land cover studies have been performed at high resolution with airborne, such as JPL AirSAR [12] and CCRS C/X SAR [13], and satellite SAR, and at global scale mainly with ERS-1/2 Wind scatterometer and the SSM/I. The potential of multi-frequency polarimetric SAR data in separating agricultural fields from other types of surfaces and in discriminating among classes of agricultural species has been demonstrated. Lee et al. exploited the land-use classification capabilities of fully polarimetric synthetic aperture radar (SAR) versus dual-polarization and single-polarization SAR for P-, L-, and C-Band frequencies. A variety of polarization combinations was investigated for application to crop and tree age classification. The authors found that L-Band fully polarimetric SAR data are best for crop classification, but that P-Band is best for forest age classification. This is because longer wavelength electromagnetic waves provide higher penetration. Moreover, the HH and VV phase difference is important for crop classification, but less important for tree age classification. Recent research addressed to urban areas by using multi-temporal analysis of SAR data, has demonstrated that the coarse resolution of ERS images does not prevent the possibility of characterizing these areas [14, 15]. [16] established the usefulness of multiple SAR views in road detection. Convenient indexes derived by the observed backscattering and brightness temperature from the ERS scatterometer and the SSM/I made it possible monitoring seasonal variations in various types of land surfaces [17],[18]. The combination of three bands of NDVI, daytime LST, and night time LST shows the highest accuracy. Three-band combination using only daytime shows lower accuracy than two bands using day and night time. Adding night time data obviously increases the accuracies of forest and built up classes. The night time data can well discriminate forest from active agriculture (or mature crops), deciduous forest in hot season from inactive agriculture (or non-mature crops), and built up from harvested or fellow agriculture [19].

b) Land use/cover classification

A supervised digital classification approach was adopted for the preparation of temporal crop and land use inventory. Cropping pattern analysis was carried out by GIS aided integration of temporal crop inventory information. In this process of matching land and use, all the constraints were examined and integrated with proper weight age according to their contribution and the possibility of making improvements considered [20]. The expert classification system is used to classify the dominant land cover types are cultivated vegetation (23%), high density urban (16%), cultivated land without vegetation (10%), and undeveloped (9%) [21] based on expert classification system earlier made by [22]for the Phoenix urban area using Landsat Thematic Mapper (TM) imagery. Two different classification methods were used: Unsupervised and supervised classification. Unsupervised classification is the identification of natural groups, or structures, within multispectral data. Supervised classification is the process of using training samples, samples of known identity to classify pixels of unknown identity [23]. This classification listing (Levels I-IV) reflects the detailed identification possible in depicting the land use, land cover and land forms [47]. With the employment of colour or false colour infrared aerial photography, a higher degree of accuracy, precision and detail can be realized. The recommended scale is 1:12,000 to 1:10,000 or larger for both the aerial photography and the graphics product (Handbook).

Descriptive and Correlation Analyses observed that while certain land use types are more generators of informal sector enterprises than others, there is a significant positive relationship between land use intensity and incidence of informal sector enterprises [24]. The authors implemented three new approaches to merging heterogeneous spatial datasets for change analysis: 1) we developed a 2000 satellite image ISODATA classification in a way that approximated the 1980 photo-interpreted classifications as closely as possible; 2) we used a third independent data set collected consistently across the two dates to constrain and improve the comparability of the classifications, and 3) we combined these in an allocation procedure. These approaches were integrated by a classification procedure that combined ISODATA clustering methods with a multi-objective land allocation procedure (MOLA), [25].

The domain concepts is used to build generic description of patterns in remote sensing images, and then use structural approaches to identify such patterns in images for detecting land use patterns in Amazonia from INPE's remote sensing image database [18].Wavelet based approach was used to detect the change in road network with the help of GIS [26]. The Neural Network (NN) classifier is tested with SPOT data for the classification [27]. The image processing system ERDAS Imagine and Idrisiw were used in processing and classifying the acquired images. Geo-referencing of images was executed on the basis of ground control points, derived from 1:100,000 scale topographical maps. An unsupervised classification of images was done first for identification of land use patterns grouping, and for grouth truthing for training site selection. A supervised classification of images was carried out using the maximum likelihood method. This decision rule is based on the probability that a pixel belongs to a particular class with the highest probability among several possibilities [28]. The comparative study of the use of unsupervised clustering algorithms for pre-classification of satellite images [29]. A decision tree classifier approach was used to extract knowledge from spatial data in the form of classification rules. The extracted knowledge was used for improving the classification accuracy. It also indicates that the knowledge extracted from this approach can solve the problem of spectral confusion to some extent. The results were compared with the maximum likelihood classification [30],[31]. A new region-merging segmentation technique was linked with this technique with the FAO Land Cover Land Use classification system resulted in the development of an automated, standardized classification methodology [32]. A multidimensional approach to classification can counteract this trend by decomposing the land into a set of fundamental and independent dimensions based on measurable characteristics which can then be used separately and in combination to provide a structured approach to classification. The approach offers the potential to develop a generic land-based classification capable of harmonizing different classification schemes and satisfying the requirements of different users. the standard maximum likelihood (ML) classifier with equal a prioris (only for the three channels case) and a special case of the ML classifier, considering proper distributions for SAR data, for the two polarimetric channels case 33],[34]. Any change in land use land cover increase the soil erosion[45] which leads to raising of the beds of rivers thus reducing their capacity and consequently spilling the flood waters in to adjoining areas, silting the reservoirs, loss of soil fertility etc. The multi-temporal ASAR imagery was first orthorectified using NTDB DEM and satellite orbital models. K Nearest neighbour (kNN) classifier was used to extract eleven land cover classes. Supervised and unsupervised classifications were performed with five training classes of water, dune, urban area, vegetation and saline soil [35]. PCA is used for the classification of SAR image ([36],[37]. The two approaches namely Van Zyl approach was used to classify the Lee filtered image pixels into three categories: (1) odd number of reflections, (2) even number of reflections, and (3) diffuse scattering and the Cloude and Pottier's target decomposition theorem was studied and employed to group all pixels into nine different zones (or nine classes) accordingly to the partitioning of the entropy (H)-alpha (x) plane. The decomposition is based on the eigen value analysis of the complex coherency matrix T, which is based on Pauli matrix representation [38], [46]. The land use sources and destination was analyzed by conversion matrix. The extent to which post-independence land use and land cover changes have influenced environmental degradation in the most environmentally sensitive sections of the Garhwal Himalayas in India, the Alaknanda Valley [39]. It reveals the trend of geographic changes and related changes in land use pattern of the estuarine island in response to the natural and anthropogenic activities [40]. It is generally recommended that a thresholding procedure be performed on the data, so that change and no-change pixels can be readily located in the change imagery. Thresholds are usually based on the number of standard deviations from the mean of the change image, typically an iterative and subjective procedure (41],[42]. Therefore, recent research has examined the selection of thresholds based on a sound statistical basis [43],[44].

III. Comparison of Various Results

Over the past decade, researchers have explored various methods which involved different fusion techniques and different classification algorithm of land use/cover classification of satellite images, few of them discussed here.

3.1 Land cover classification by combination of SAR and optical data Obviously, solely application of optical data as stated in previous paragraph enables to establish good land cover map, however, there are still some misclassification and the result needs to be refined for practical use. Combining analysis results of both optical and JERS-1 SAR we could obtain the best result.

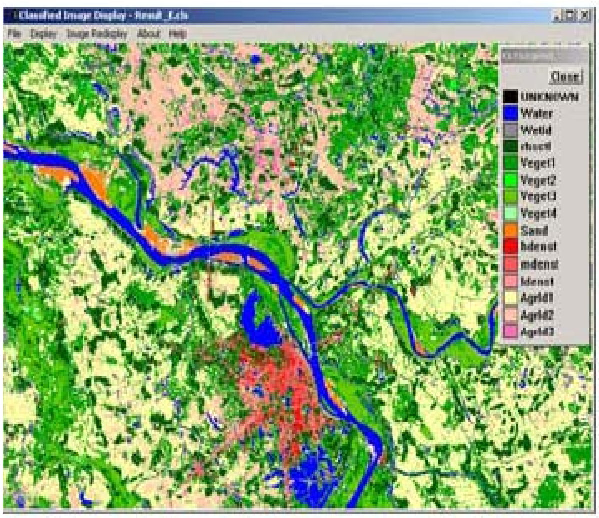
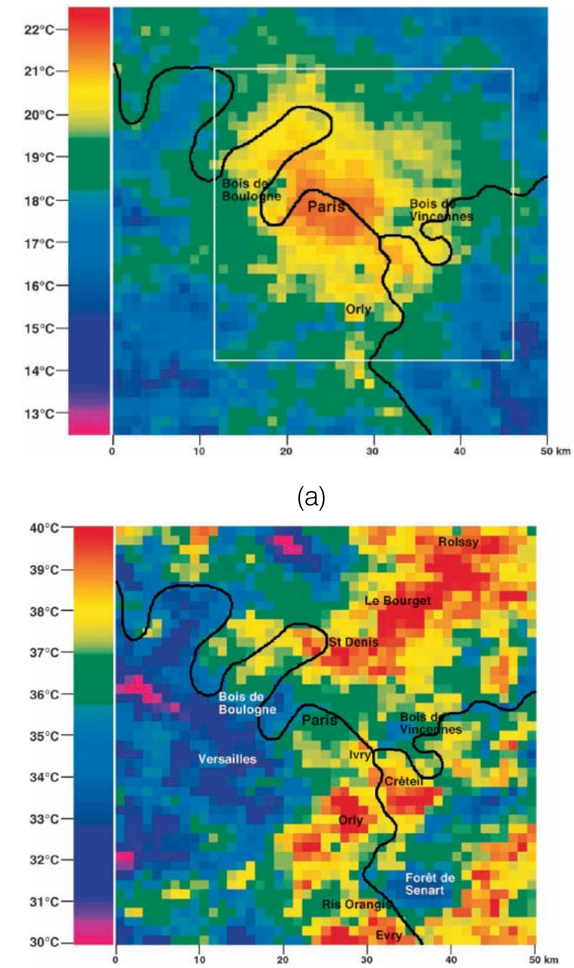


Figure 1 : Land cover map established by combination of optical and microwave data

3.2 Land evaluation may be defined as: "the process of assessment of land performance when the land is used for specified purposes"(Food and Agriculture Organization of the United Nations, 1985. The crop and other land use- land cover pattern of a region is an outcome of both natural and socio-economic factors and their utilization by man in time and space. Land is becoming a scarce commodity due to immense agricultural and demographic pressure. Hence, information on land use-land cover and possibilities for their optimal use is essential for the selection, planning and implementation of land uses schemes to meet the increasing demands for basic human needs and welfare. Increasing human interventions and unfavourable bioclimatic environment has led to transformation of large tracts of land into wastelands. Satellite remote sensing plays an important role in generating information about the latest land use-land cover pattern in an area and its temporal changes through times.

3.3 The land cover classification at 20-m resolution allows one to compute the percentage of a given class within 1-km resolution AVHRR pixels. Fig. 3a shows the percentage of the ''densely built'' class over Paris, and Fig. 3b displays its joint distribution with night and day average LST images. The night time distribution of LST is well correlated with the increasing density of buildings from the suburbs to downtown, as seen in Fig. 2a. The daytime distribution of LST also shows a correlation with density of building, although the variance is larger, presumably due to larger fluctuations of the heat fluxes, hence of LST, under the stronger radiative forcing conditions.



(a)

(b)

Figure 2 : Night time average image of Paris LST based on five NOAA-AVHRR thermal IR images at 03:27 UTC, August 6 –10, 1998.

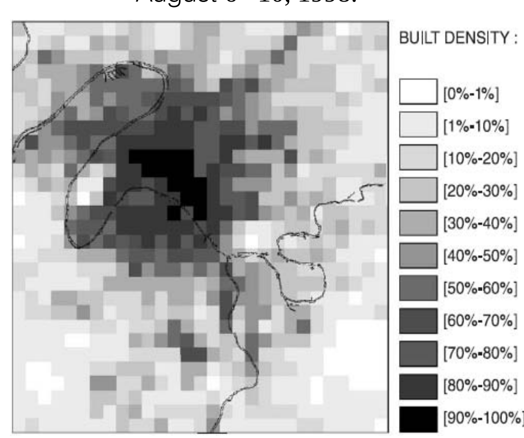


Figure 3 : (a) Percentage of densely built class (incl. roads) at 1-km resolution, derived from the 20-m resolution land cover classification of Paris. (b) Joint distribution of percentage of the densely built class, with night time and daytime average LST images (Fig. 2a and b).

3.4 Three different sensors (Landsat MSS, TM, ETM) image of Lahore City of Pakistan which is situated within the geographic extents of (74°east to 74°39'23"east) longitude and (31° 13'18"north to 31°43'north) latitude, the expanse of Lahore district encompasses an area of 1772sqkm. The higher levels of accuracies were achieved in case of Landsat MSS Image Dataset because that image contained more spectrally separable features than those were in the image datasets of the later dates. Difference in Spectral, spatial and radiometric resolutions of each datasets could also be one of the reasons for varying classification success rates. Diminishing vegetation can be observed in the direction of population expansion, the agricultural land is successively being converted into commercial/ residential areas for potential construction of houses, apartments and plazas. Moreover, as obvious from the classified image datasets, areas of sparse population convert into those of thick population over a period of 5-10 years. Hence transformation occurs from spacious to congested city environs and from rural agriculture land to urban residential/commercial land within the district.

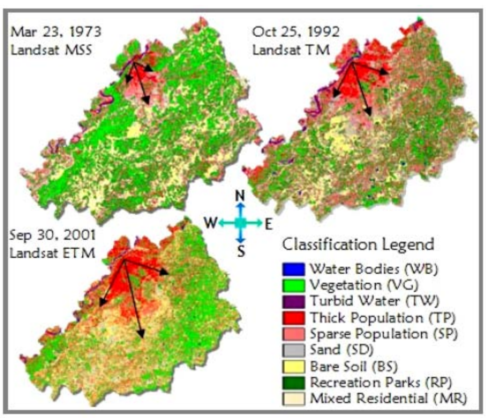


Figure 4 : Supervised image Classification showing Extent and Direction of Population Growth in the Study Area

3.5 A multi-spectral SPOT image, polarimetric airborne SAR data as well as satellite based C-band SAR data have been used to perform classification of agricultural fields and areas occupied by forest and lake with Conventional Maximum Likelihood classification and classification incorporating a Gaussian mixture class model, as well as an algorithm based on multi-resolution structured data and sequential MAP (SMAP).

Figure 5 : Classified image based on the total data set Average accuracy is 95.9%.

Class	Label	pixels in training set	pixels in test set
1	rye	11535	12350
2	oat	21899	11709
3	wheat	31278	27983
4	winter barley	12358	12866
5	grass	10916	8753
6	oil seed rape	27942	27989
7	forest	24014	28336
8	lake	12723	11347

Table 1 : Number of pixels in training and test fields used in the classifications

The standard maximum likelihood (ML) classifier with equal priories (only for the three channels case) and a special case of the ML classifier, considering proper distributions for SAR data, for the two polarimetric channels case. The Support Vector Machine classifier (SVM) with Radial Basis Functions Kernel, was selected as the deterministic pixel based classifier representative. 3.6 Multisource and Multitemporall Data in Land Cover Classification Tasks: the Advantage Offered by Neural Networks

The experiment was carried out with different set of classes and multi-layer feed forward neural networks, trained by means of the Error Back Propagation algorithm with different numbers of internal, hidden and output neurons. the accuracy of the classification can be strongly increased, if four microwave images are available, as happens in mid July. The result is given below in the table:

Class	Commission (%)	Omission (%)
Grassland	31.13	34.74
Oat	60.43	47.77
Spring barley	66.32	69.07
Forest	76.62	78.05
Winter Barley	42.97	55.25
Winter Wheat	69.37	49.95
Moorland	67.07	78.38
Urban	75.51	62.82
Water	98.62	93.97
Overall (%)	66.73	

Table 2 : Classification accuracy (S3, June)

Class	Commission (%)	Omission (%)
Grassland	87.50	79.21
Oat	72.32	67.35
Spring barley	84.72	78.80
Forest	91.34	92.02
Winter Barley	84.83	70.12
Winter Wheat	71.61	84.09
Moorland	80.71	89.28
Urban	81.89	75.21
Water	96.04	95.28
Overall (%)	83.18	

Table 3 : Classification accuracy (S 1-S2-E1, May)

Class	Commission (%)	Omission (%)
Grassland	66.77	56.01
Oat	65.30	49.65
Spring barley	59.30	55.01
Forest	68.30	82.79
Winter Barley	58.74	41.05
Winter Wheat	64.39	71.16
Moorland	60.37	63.64
Urban	73.82	86.08
Water	99.33	92.04
Overall (%)	69.07	

Table 4 : Classification accuracy (E2-S3-E3, June)

Class	Commission (%)	Omission (%)
Grassland	78.48	78.68
Oat	88.03	70.79
Spring barley	80.70	88.63
Forest	90.02	91.15
Winter Barley	74.79	78.28
Winter Wheat	82.32	81.57
Moorland	86.74	82.29
Urban	80.19	83.87
Water	99.45	94.36
Overall (%)	84.58	

Table 5 : Classification accuracy (S2-El-E2-S3-E3-E4, July)

3.6 The combination of unsupervised and supervised classification was used. In the land use classification generated using Arc View tools; the distribution of land use is the following: the predominant land use of the area is forest, followed by herbaceous rangeland, followed by agriculture, and a small portion of the watershed composed an urban area. In this classification the rangeland area that is located in the center of the watershed can not be observed.

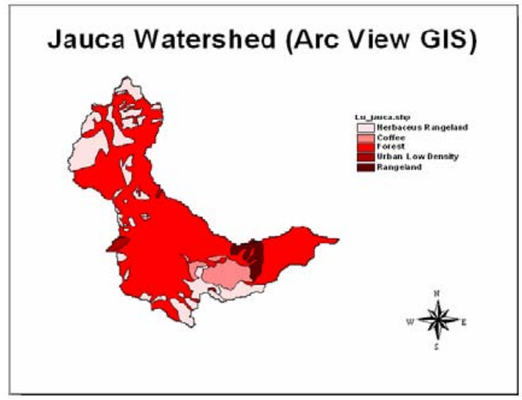


Figure 6 : Arc View GIS, Land Use Classification of Río Jauca

The procedure produced a final raster image with each pixel classified into a land-use class/cluster and each land-use class/cluster having the expected number of pixels determined from the NRI-LUDA relationship. Clusters were then aggregated to the desired output Level I land-cover categories. We used a sample of NAPP interpreted photos for validation. Results showed that the approaches we adopted in order to produce comparable classifications improved on AVHRR classifications alone.

3.7 The best kNN was achieved with combined Mean and Standard Deviation with multi-incidence angle, dual polarization eleven date ASAR images. ANN further improved the classification results of the textured images. As for comparison of classifiers, It was found that, with complex combinations (dual polarization, multi-incidence angle), ANN performs significantly better than kNN. The overall accuracy was 9.6% higher than that of kNN.

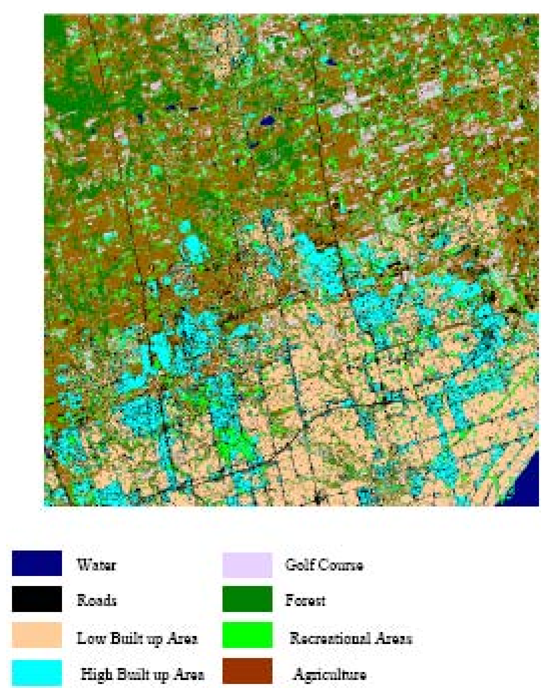


Figure 7 : Classified TM Images 1988

3.8 The Basic statistics index, fragmentation index, fractal dimension and diversity index was applied on the TM imagery of years 86, 96 and 2000 of the Haikou City. The 96 imagery was geo-rectified based on 1:100,000 DEM.

3.9 A principal component analysis was performed on a subset of the southern part of the Netherlands. In addition, the correlation coefficients between the 15 MERIS bands were mutually calculated. Subsequently, training samples for the main land cover classes were collected using the aggregated Dutch land cover data base as a reference. Per class two polygons of about 50 pixels each were identified in rather homogeneous areas. Thereafter the spectral signatures were studied. Finally, a minimum distance-to-means supervised classification was performed including clouds as a separate class in the training stage. In a post-processing step, the two subclasses per main cover class were merged.

The results of a minimum-distance-to-means (MDM) classification for the Netherlands, including also a class "clouds" in the training set. Classification accuracies were determined by using the whole land cover data base (Figure 2) as a reference. Table 5 shows the results for the main land cover classes (without classes bare soil and horticulture as indicated before). Results show a moderate overall classification accuracy of 49.7%.

3.10 After implementing all clustering procedures with the same initialisation conditions, we subtract the resulting clustering images from our reference image. The subtraction for each image was carried out by assigning the 9 clustering classes to the 5 reference classes and subtracting the clustered image from the classified image, pixel-by-pixel. As an example, Figure 8(a) shows the agglomerative hierarchical clustering result for 9 classes, and Fig. 2(b) the differenced image. The FMLE and AHC methods performed similarly well, with 11% and 10% discrepancies respectively in the differenced images. This is to be compared with 28% and 23% for the CM and FCM algorithms, respectively. We conclude that Fuzzy-Maximum-Likelihood and Agglomerative Hierarchical Clustering are superior to the more commonly-used C-Means and Fuzzy-C-Means Clustering for pre-classification analysis of LANDSAT satellite images. The problem of choosing the number of clusters remains a difficult one.

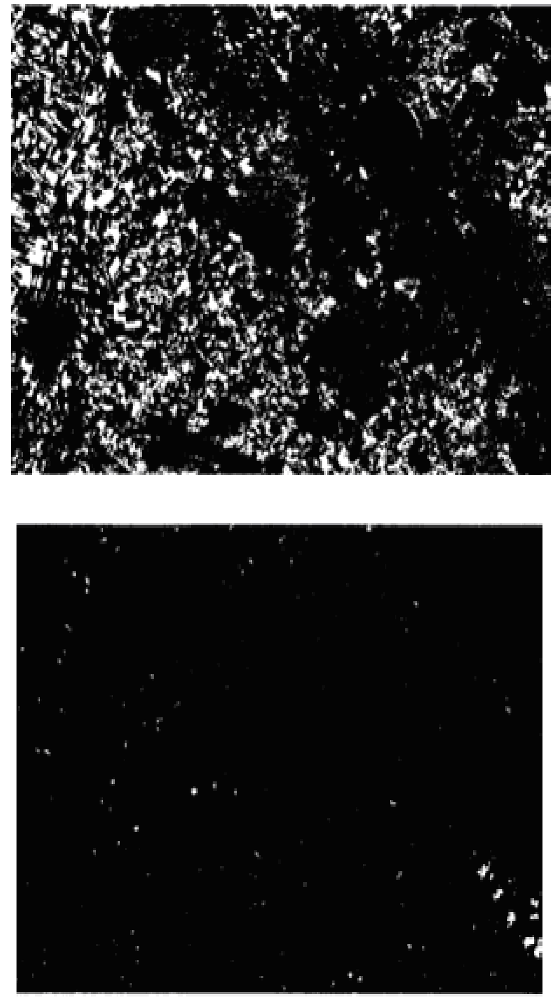


Figure 8 : (a) Classification result; (b) subtraction result

3.11 Road change detection and database updating based on wavelet and map conflation techniques was proposed for the satellite image of the 5.8 m IRS panchromatic image covering the urban area of Ottawa (ON, Canada).

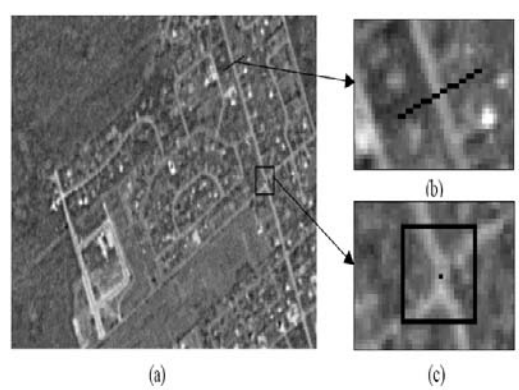


Figure 9 : Part of the IRS panchromatic image

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Figure 10 : Road centerlines extracted from IRS pan image of urban area (red dashed line) superimposed with NTDB roads (green solid line)

IV. Conclusion

Generally, the accuracy of land cover classification depends on two factors. One is the amount of the spectral information provided by the input remotely sensed data, the other is the classification approach. For the same set of input remote sensing data, different classification approaches may have quite different accuracies. This is important because land cover and land use data products play an important role in quantitative modelling of carbon cycle and climate change. Input map accuracy is closely related to output uncertainties from these models.

Human error digitizing, lack of knowledge of study area, and other factors all contribute to inaccurate results in the supervised classification method. In any case, the resulting images are useful for some applications such as generating estimates on relative presence of water bodies, agricultural land use, and forested areas. If more accurate results are desired, additional processing to tease out specific land use patterns may be possible by detailed examination of the image and data. This technique requires more work and may not produce results that better represent what is actually present in the field. When using any classification technique, it is best to use additional references of the study area rather than only the satellite imagery. Without comparing these images to maps, aerial photographs, and actual visits to the study area, features actually present cannot be determined. The use of USGS Digital Line Graphs (DLG) (line map data in digital form) would be helpful in isolating out features such as asphalt and concrete. DLG hydrological maps contain information on transportation, flowing water, standing water, and wetlands further easing the job of classification. Also available from the USGS are Multi-resolution Land Classification (MRLC) maps. MRLC data are derived from Landsat 7 TM data. Landsat 7 TM has several advantages over pervious Landsat satellites including better resolution and an additional thermal band. These maps are available at reasonable price and already have land use classified into 21 different land use classes. The image fusion technique better result compare to conventional techniques because the in the cloudy season it works well compare to conventional method.

References Références Referencias

1. CEC, '*CORINE land cover; Technical guide*, Luxembourg, Office for Official Publications of the European Communities', 1994.
2. B. Dousset and F. Gourmelon,' Satellite multi-sensor data analysis of urban surface temperatures and landcover', ISPRS Journal of Photogrammetry & Remote Sensing, 2003, 58, pp 43– 54.
3. Nguyen Dinh Duong, 'Improvement of Land Cover / Land Use Classification by Combination of Optical and Microwave Remote Sensing Data', Proceeding of the workshop on Methodology, 2004, Vietnam.
4. Amjed S. Almas , C. A. Rahim , M. J. Butt, and Tayyab I. Shah, 'METROPOLITAN GROWTH MONITORING AND LANDUSE CLASSIFICATION USING GEOSPATIAL TECHNIQUES', Proceeding of the International workshop(ISPRS) on Service and Application of Spatial Data Infrastructure, XXXVI(4/W6), Oct.14-16, 2005,Hangzhou, China.
5. Xue Liu, Menas Kafatos and Richard B. Gomez, 'Combining MISR, ETM+ and SAR data to improve land cover and land use classification for carbon cycle research', Proceeding of IEEE, 2004.
6. Inge Sandholt, 'The combination of polarimetric SAR with satellite SAR and optical data for classification of agricultural land', Geografisk Tidsskrift, Danish Journal of Geography 101, 2001.
7. Alaaddin Yüksel, Abdullah E. Akay and Recep Gundogan, 'Using ASTER Imagery in Land Use/cover Classification of Eastern Mediterranean Landscapes According to CORINE Land Cover Project', *Sensors,* 2008, *8*, pp.1237-1251.
8. Othman, M. T., J. J. Legarsky and C. H. Davis, 'Microwave and Optical Remote Sensing Study of Boone County, Missouri', International Symposium on Geoscience and Remote Sensing (IGARSS '02), IEEE, 2002.
9. Barry Haack and Matthew Bechdol , 'integrating multisensor data and RADAR texture measures for land cover mapping', Journal of Computers & Geosciences 2006, 26, pp 411-421.
10. F. D. VESCOVI and M. A. GOMARASCA, 'INTEGRATION OF OPTICAL AND MICROWAVE REMOTE SENSING DATA FOR AGRICULTURAL LAND USE CLASSIFICATION', Environmental Monitoring and Assessment 58: 133–149, (1999, Kluwer Academic Publisher, Printed in the Netherlands).
11. K S Ranjan and Ryosuke Shibasaki, 'A GIS based Integrated Land Use/Cover Change model to Study

Agricultural and Urban Land Use Change', Proceeding of 22nd Asian Conference on Remote Sensing, 5-9 November, 2001, Singapore.

12. G. Macelloni, S. Paloscia, P. Pampaloni, and E. Santi, 'Global Scale Monitoring of Soil and Vegetation Using Active and Passive Sensors', International Journal Remote Sensing, 2003, 24(12), pp. 2409-2425.
13. J. S. Lee, M. R. Grunes and Eric Pottier, 'Quantitative Comparison of Classification Capability: Fully Polarimetric Versus Dual and Single-Polarization SAR', IEEE Transactions on Geoscience and Remote Sensing, November 2001, GRS-39(11), pp. 2343-2351.
14. F. Dell'Acqua and P. Gamba, 'Texture-Based Characterization of Urban Environments on Satellite SAR Images', IEEE Transactions on Geoscience and Remote Sensing, GRS-41(1), January 2003, pp. 153-159.
15. G. Franceschetti, A Iodice, D. Riccio, 'A canonical problem in electromagnetic backscattering from buildings IEEE Transactions on Geoscience and Remote Sensing', GRS40(8), August 2002, pp 1787 -1801.
16. F. Tupin, B. Houshmand, and M. Dactu, 'Road Detection in Dense Urban Areas Using SAR Imagery and the Usefulness of Multiple Views', IEEE Transactions on Geoscience and Remote Sensing, GRS-40(11), November 2002, pp. 2405-2414.
17. P.L. Frison, E. Mougin, L. Jarlan, M. A. Karam, and P. Hiernaux, 'Comparison of ERS Wind-Scatterometer and SSM/I Data for Sahelian Vegetation Monitoring', IEEE Transactions on Geoscience and Remote Sensing, GRS-38(4), July 2000, pp. 1794-1803.
18. Marcelino Pereira S. Silva, Gilberto Câmara, Ricardo Cartaxo M. Souza, Dalton M. Valeriano, Maria Isabel S. Escada, 'Mining Patterns of Change in Remote Sensing Image Databases', Proceedings of the Fifth IEEE International Conference on Data Mining (ICDM'05), 2005.
19. Chada Narongrit, Mitsuharu Tokunaga, Shunji Murai, Kaew Nualchawee, Apisit Eiumnoh and Suphat Vongvisessomjai, 'Additional Nighttime Avhrr Data for Classifying Land Cover Types in Thailand', Proceeding of the ACRS Conference, 2000, 4-8 October, Taipei, Taiwan.
20. SWAGATA CHOUDHURY and S K Saha, 'Cropping Pattern Change Analysis And Optimal Landuse Planning By Integrated Use Of Satellite Remote Sensing And GIS -A Case Study Of Barwala C.D. Block , Panchkula District, Haryana', Indian Cartographer, 2003.
21. Maik Netzband, Elizabeth L. Wentz and Atiqur Rahman, 'URBAN LAND COVER AND SPATIAL VARIATION OBSERVATION USING SATELLITE IMAGE DATA – THE URBAN ENVIRONMENTAL MONITORING PROJECT', 2003.
22. Stefanov, W.L., & Netzband, M., Characterization and monitoring of urban/peri-urban ecological function and landscape structure using satellite data. In Jürgens, C., and Rashed, T. (eds.), *Remote sensing of urban and suburban areas*. Dordrecht: Kluwer Academic Publishers (in press).
23. Edwin Martínez Martínez, 'REMOTE SENSING TECHNIQUES FOR LAND USE CLASSIFICATION OF RIO JAUCA WATERSHED USING IKONOS IMAGES', Project report Agricultural and Biosystems Engineering Department, University of Puerto Rico-Mayagüez, 2004.
24. M. O. Jelili and A. A. Adedibu, 'Land Use Classification and Informal Sector Question in Ogbomoso', Nigeria J. Hum. Ecol., 2006, 20(4), pp 283-287.
25. Kathleen M. Bergen, Daniel G. Brown, James R. Rutherford and Eric J. Gustafson, 'Development of a Method for Remote Sensing of Land-Cover Change 1980-2000 in the USFS North Central Region Using Heterogeneous USGS LUDA and NOAA AVHRR 1 km Data', Proceeding of IEEE, 2002.
26. Zhang Qiaoping and Isabelle Couloigner, 'Automatic road change detection and GIS updating from high spatial remotely-sensed imagery', Journal of Geo-Spatial Information Science, 2004, 7(2) June, pp 89-95.
27. Alessandra Chiuderi, 'Multisource and Multitemporall Data in Land Cover Classification Tasks: the Advantage Offered by Neural Networks', IEEE, 97.
28. Võ Quang Minh, Nguyễn Thị Hồng Điệp, Nguyễn Thị Đượm, 'Application of SPOT Quicklook satellite images to identify and delineate the changing of land use in the coastal zone of Camau Peninsula Vietnam', Proceeding of AARS, 2005, Hanoi, Vietnam.
29. Tanja Duda and Morton Canty, 'Unsupervised Land-Use Classification of Multispectral Satellite Images' A Comparison of Conventional and Fuzzy-Logic Based Clustering Algorithms, Proceeding of IEEE, 1999.
30. Sameer Saran, Amit Bharti, Geert Sterk and P.L.N. Raju, 'Comparing and optimizing land use classification in a Himalayan area using parametric and non parametric approaches', Journal of Geomatics, 2007, 1(1), pp 30-38.
31. Rogan, J., Miller, J., Stow, D., Franklin, J., Levien, L., Fischer, C., 'Land cover change mapping in California using classification trees with Landsat TM and ancillary data', Journal of Photogrammetric Engineering and Remote Sensing, 2003,69(7), pp 793–804.
32. Ruvimbo Gamanya, Philippe De Maeyer and Morgan De Dapper, 'An automated satellite image classification design using object-oriented segmentation algorithms: A move towards

standardization', Journal of Expert Systems with Applications, 2007, 32(2), pp 616–624.
33. Luciano Vieira Dutra, Corina da Costa Freitas, Graziela Balda Scofield, José Cláudio Mura, Sumaia Resegue Aboud Neta, Rogério Galante Negri, João Roberto dos Santos, Marcos Timbó Elmiro, Sydney Sant'Anna, 'ASSESSMENT ON THE IMPROVEMENT OF THE LAND USE/LAND COVER CLASSIFICATION IN AMAZON USING ALOS PALSAR POLARIMETRIC DATA', International Symposium on Geoscience and Remote Sensing (IGARSS '08), IEEE, 2008.
34. Rogan, J., Franklin, J., Roberts, D.A., 'A comparison of methods for monitoring multitemporal vegetation change using Thematic Mapper imagery', Journal of Remote Sensing of Environment, 2002, 80(1), pp 143–156.
35. Takashi KUME, Kiyoshi TORII and Toru MITSUNO, 'Approach to Land-use Analysis in Hetao Irrigation Project of Inner Mongolia, China, Based on Satellite Image Data', Proceeding of the ACRS Conference, 2000.
36. Hussam AL- Bilbisi and Ryutaro Tateishi, 'A study on land use/cover classification with textural analysis using Multi-Temporal JERS-1 (SAR) L-band in arid and semi-arid areas.(A case study in Northeastren Jordan)', Proceeding of the ACRS Conference, 2002 Kathmandu, Nepal.
37. Jan Clevers, Harm Bartholomeus, Sander Mücher and Allard de Wit, 'LAND COVER CLASSIFICATION WITH THE MEDIUM RESOLUTION IMAGING SPECTROMETER (MERIS)', Proceeding of EARSeL, 2004, 3(3),pp 354-362.
38. Ken Yoong LEE, Soo Chin LIEW and Leong Keong KWOH, 'Land cover classification and interpretation of NASA / JPL AIRSAR data based on scattering mechanisms and statistical distribution', Proceeding of the ACRS Conference, 2002, Kathmandu, Nepal.
39. Sushmita Saha and Keith Richards, 'Land Use and Land Cover Change: A Spatio-Temporal Study of The Alaknanda Valley, Garhwal Himalayas, India', Proceeding of 22nd Asian Conference on Remote Sensing, 5-9, November, 2001, Singapore.
40. Tuhin Gosh, Gupinath Bhandari and Sugata Hazra, 'Assessment of Landuse/landcover dynamics and Shoreline changes of Sagar Island through Remote Sensing', Proceeding of 22nd Asian Conference on Remote Sensing, 5-9 November,2001, Singapore.
41. Lunetta, R.S., Ediriwickrema, J., Johnson, D., Lyon, J.G., McKerrow, A., 'Impacts of vegetation dynamics on the identification of land-cover change in a biologically complex community in North Carolina, USA', Remote Sensing of Environment 2002, 82(2-3), pp 258–270.
42. Rogerson, P.A.. , 'Change detection thresholds for remotely sensed images', Journal of Geographical Systems, 2002, 4 (1) March, pp 85–97.
43. J. S. Lee, M. R. Grunes and Eric Pottier, 'Quantitative Comparison of Classification Capability: Fully Polarimetric Versus Dual and Single-Polarization SAR', IEEE Transactions on Geosciences and Remote Sensing, November 2001, GRS-39(11), pp. 2343-2351.
44. J. V. Fiore and N. C. Grody, 'Classification of Snow Cover and Precipitation Using SSM/I Measurements: Case Studies', International Journal of Remote Sensing, 1992, 13(17), pp. 3349-3361.
45. S.P.Aggarwal,WRD, Land use land cover change and its impact on soil erosion, Annual report of the ongoing Project in Indian Institute of Remote Sensing, India.
46. Tian Guangjin, Liu Jiyuan and Zhang Zengxiang, 'Dynamic change of land use structure in Haikou by remote sensing', Proceeding of 22nd Asian Conference on Remote Sensing, 5-9, November, 2001, Singapore
47. Janne Heiskanen, 'Remote sensing of boreal land cover: estimation of forest attributes and extent, Thesis, Department of Geography', Faculty of Science, University of Helsinki, Finland, 2008.

Table 6 : Confusion matrix for supervised classification of TM 1988 image using kNN Classifier

Name	Water	Roads	LD	HD	Golf	Forest	Parks	Agriculture
Water	**100**	0	0	0	0	0	0	0
Roads	0	**93.8**	3.6	2.4	0	0	0	0.2
LD	0	17.4	**82.2**	0.5	0	0	0	0
HD	0	18.4	2.6	**79**	0	0	0	0.1
Golf	0	0	0	0	**80.6**	4.2	1.9	13.3
Forest	0	0	0	0	0	**100**	0	0
Parks	0	1.2	0.2	1.8	0	0	**96.8**	0
Agriculture	0	0.2	0	0	14.2	0	2.7	**82.9**

Average accuracy = 89.42%
Overall accuracy = 87.13%
Kappa Coefficient = 0.84345 Standard Deviation = 0.00409
Confidence Level:
99% 0.84345 +/- 0.01056
95% 0.84345 +/- 0.00802
90% 0.84345 +/- 0.00673

Table 7 : The landscape characteristics of land use change in the Haikou City

Year	1986				2000			
Land type	A_i	n	Pa	D	A_i	n	Pa	D
Cultivated	8178.86	30	272.63	1.302	5081.91	33	154.00	1.298
Forest	6474.92	43	150.58	1.328	5955.12	49	121.53	1.252
Grass	377.41	13	29.03	1.394	377.41	13	29.03	1.386
Water	2479.07	17	145.83	1.326	389.59	18	21.64	1.258
Urban	2805.21	19	147.64	1.296	8719.26	6	1453.21	1.212
Rural	253.31	19	13.33	1.273	493.34	23	21.45	1.285
Construction	1155.08	19	60.79	1.326	1755.14	20	87.76	1.390
Unused	950.92	5	190.18	1.258				

Table 8 : Results of a principal component analysis on a subset of the MERIS image of June 16th, 2003.

Principal component	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
Explained variance /%	86.03	12.64	0.59	0.38	0.18	0.09	0.04	0.02	0.02	0.01	0.00	0.00	0.00	0.00	0.00

Table 9 : Correlation matrix for a subset of the MERIS image of June 16th, 2003.

r	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
1	1														
2	.990	1													
3	.961	.990	1												
4	.944	.979	.996	1											
5	.860	.906	.938	.961	1										
6	.852	.907	.948	.969	.975	1									
7	.835	.891	.934	.954	.945	.993	1								
8	.831	.887	.932	.951	.941	.991	.999	1							
9	.632	.688	.735	.780	.914	.861	.824	.821	1						
10	-.011	.002	.010	.046	.261	.085	.009	.004	.515	1					
11	.054	.078	.096	.121	.302	.128	.043	.040	.497	.944	1				
12	-.069	-.061	-.057	-.019	.199	.025	-.047	-.052	.465	.994	.914	1			
13	-.087	-.079	-.075	-.034	.179	.007	-.064	-.068	.458	.990	.912	.997	1		
14	-.066	-.057	-.052	-.016	.198	.025	-.049	-.053	.471	.992	.930	.993	.998	1	
15	-.126	-.108	-.093	-.057	.157	-.013	-.087	-.091	.437	.980	.946	.977	.984	.989	1

Table 10 : Classification results for the MERIS image of June 16th, 2003.

	Producer's Accuracy	User's Accuracy
Grassland	35.2 %	61.2 %
Arable land	62.4 %	36.4 %
Deciduous forest	25.4 %	12.2 %
Coniferous forest	43.3 %	36.4 %
Natural vegetation	16.5 %	8.2 %
Built-up	24.4 %	51.3 %
Water	85.6 %	96.3 %
Overall Accuracy = 49.7 %		Kappa coefficient = 0.369

Table 11 : Results of classification into only 4 main classes for the MERIS image of June 16th, 2003.

	Producer's Accuracy	User's Accuracy
Agriculture	88.5 %	88.1 %
Forest	56.1 %	28.6 %
Built-up	24.4 %	51.3 %
Water	85.6 %	96.3 %
Overall Accuracy = 78.1 %		Kappa coefficient = 0.622

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Investigations on Microsilica (Silica Fume) As Partial Cement Replacement in Concrete

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Abstract - Now a day, we need to look at a way to reduce the cost of building materials, particularly cement is currently so high that only rich people and governments can afford meaningful construction. Studies have been carried out to investigate the possibility of utilizing a broad range of materials as partial replacement materials for cement in the production of concrete. This study investigated the strength properties of Silica fume concrete.

Keywords : *Concrete, Silica Fume/Micro Silica, Compressive Strength, Density.*

GJRE-E Classification : *FOR Code: 090503*

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Strictly as per the compliance and regulations of:

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Abstract - Now a day, we need to look at a way to reduce the cost of building materials, particularly cement is currently so high that only rich people and governments can afford meaningful construction. Studies have been carried out to investigate the possibility of utilizing a broad range of materials as partial replacement materials for cement in the production of concrete. This study investigated the strength properties of Silica fume concrete.

The specific gravity and chemical composition of silica fume and cement were replaced with micro silica from 0 to **25%** in steps of **5%** by weight, mix proportioning was based on **1:2:4** mix ratio. Cubes **(150 x 150 x 150 mm)** were produced and cured in a curing tank for **3, 7, 14** and **28** days. The cubes were subjected to compressive strength tests after density determination at **3,7,14** and **28** days respectively. The chemical composition and physical composition of micro silica and cement were determined. Ordinary Portland cement was replaced with silica fume. The total amount of Tricalcium aluminate in the cement was **7.7%** and this was above the requirement. (Table **3.1** shows **3.5** max, Specified by **BS12/EN196:1996)**,others chemical compositions for silica fume such as **SiO_2**, moisture content, loss of ignition, carbon, > 45 micron, bulk density. Tables 3.1 were within the specified limit. Also % chemical composition and physical properties for **SiO_2, Al_2O_3, Fe_2O_3,CaO, MgO, SO_3,** Alkalis (**Na_2O + 0.658K_2O),** loss of ignition (Lo1), insoluble residue (IR), Tricalcium, silicate, Dicalcium silicate, **CaO / SiO_2,** chloride, fineness (Blaine air permeability test) in **Cm^2/g,** soundness (mm) table 3.1 were in compliance with BS Standard. The density of the concrete decreased with increased in percentage of micro silica replacement up to **10%**. Increase in the level of micro silica fume replacement between 15% to **25%** led to a reduction in the compressive strength of hardened concrete (table 3.3)

This study has shown that between **5** to **10%** replacement levels, silica fume concrete will develop strength sufficient for construction purposes. Its use will lead to a reduction in cement quantity required for construction purposes and hence sustainability in the construction industry as well as aid economic construction.

Keywords :Concrete, Silica Fume/Micro Silica, Compressive Strength, Density.

I. Introduction

It was observed and noted that since decade of years that the cost of building materials is currently so high that only corporate organizations, individual, and government can afford to do meaningful construction. Waste can be used as filler material in concrete, admixtures in cement and raw material in cement clinker, or as aggregates in concrete (Olutoge, 2009).

Ordinary Portland cement (OPC) is acknowledged as the major construction material throughout the world. The production rate is approximately 2.1 billion tons per year and is expected to grow to about 3.5 billion tons per year by 2015 (Coulinho, 2003). According to Adepegba (1989), the annual cement requirement in Nigeria is about 8.2 million tones and only 4.6 million tones of Portland cement are produced locally. The balance of 3.6 million tonnnes or more is imported. If aiternative cheap cement can be produced locally, the demand for Portland cement will reduce. The search for suitable local materials to manufacture pozzolana cement was therefore intensified (Adepegba, 1989). Most of the increase in cement demand could be met by the use of supplementary cementing materials, in order to reduce the green gas emission (Bentur, 2002). Industrial wastes, such as silica fume, blast furnance slag, fly ash are being used as supplementary cement replacement materials and recently, agricultural wastes are also being used as pozzolanic materials in concrete (Sensale, 2006). When pozzolanic materials are incorporated to concrete, the silica present in these materials react with the calcium hydroxide released during the hydration of cement and forms additional calcium silicate hydrate (C – S – H), which improve durability and the mechanical properties of concrete

(Igarashi et al, 2005). High strength concrete refers to concrete that has a uniaxial compressive strength greater than the normal strength concrete obtained in a particular region. High strength and high performance concrete are being widely used throughout the world and to produce them, it is necessary to reduce the water binder ratio and increase the binder content. High strength concrete means good abrasion, impact and cavitations resistance. Using high strength concrete in structures today would result in economical advantages.

In future, high range water reducing admixtures (Super plasticizer) will open up new possibilities for use of these materials as a part of cementing materials in concrete to produce very high strengths, as some of them are make finer than cement. The brief literature on the study has been presented in following text.

(Hooten RDC, 1993) investigated on influence of silica fume replacement of cement on physical properties and resistance to sulphate attack, freezing

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and thawing, and alkali silica reactivity. He reported that the maximum 28 days compressive strength was obtained at 15% silica fume replacement level, at a W/C ratio of 0.35 with variable dosages of HRWRA. (Prasad et al, 2003), has undertaken an investigation to study the effect of cement replacement with micro silica in the production of high – strength concrete.

(Yogendran et al, 1987), investigated on silica fume in high – strength concrete at a constant water binder ratio (w/b) of 0.34 and replacement percentages of 0 to 25, with varying dosages of HRWRA. The maximum 28 day compressive strength was obtained at 15% replacement level. (Lewis et al, 2001) presented a broad overview on the production of micro silica effect of standardization of micro silica concrete both in the fresh and hardened state.

(Bhanja et al, 2003) reported and directed towards developing a better understanding of the isolated contributions of silica fume concrete and determining its optimum content. Their study intended to determine the contribution of silica fume on concrete over a wide range of w/c ratio ranging from 0.26 to 0.42 and cement replacement percentages from 0 to 30.

(Tiwari et al, 2000) presented a research study carried out to improve the early age compressive strength of Portland slag cement (PSC) with the help of silica fume. Silica fume from three sources: one imported, two indigenous were used in various proportions to study their effect on various properties of PSC.

II. Methodology

The methodology adopted comprised of both preliminary and experimental investigations carried out using the study material and these are presented as follows:

a) Preliminary Investigations

For the preliminary investigations, micro silica and cement was subjected to physical and chemical analyses to determine whether they are in compliance with the standard used.

The experimental program was designed to investigate silica fume as partial cement replacement in concrete. The replacement levels of cement by silica fume are selected as 5%, 10%, 15%, 20%, and 25% for standard size of cubes for the C30 grade of concrete. The specimens of standard cubes (150 x 150 x 150 mm), was casted with silica fume. Compressive machine was used to test all the specimens. The specimens were casted with C30 grade concrete with different replacement levels of cement from 0 to 25% with silica fume. Seventy two samples was casted and the cubes were put in curing tank for 3, 7, 14, and 28 days and density of the cube, and compressive strength were determined and recorded down accordingly. The other materials used are listed as follow:

- Cement

Ordinary Portland cement produced by QNCC was used in this study. The cement conformed to the requirements of BS 12 (1996).

- Aggregates

There are the inert filler in the concrete mixture which constitute between 70 – 75% by volume of the whole mixture. The sand used was collected within Ibadan metropolis, Nigeria. It was clean and free from organic material and clay. The coarse aggregate used were mainly material retained on a 4.7mm BS 410 test sieve and contained only so much fine materials as was permitted for various sizes in the specification.

- Water

The water used for the study was free of acids, organic matter, suspended solids, alkalis and impurities which when present may have adverse effect on the strength of concrete.

ure 2.1 : Showing Micro Silica in a sample Pan.

b) Preparation of Specimens

In this study, a total number of 12 cubes for the control and cement replacement levels of 5%, 10%, 15%, 20% and 25% were produced respectively. For the compressive strength, 150mm x 150mm x 150mm cubes mould were used to cast the cubes and 3 specimens were tested for each age in a particular mix (i.e. the cubes were crushed at 3, 7 ,14 and 28 days respectively). All freshly cast specimens were left in the moulds for 24 hours before being de – moulded and then submerged in water for curing until the time of testing. Table 2.1 shows the number of specimens cast and the testing arrangement.

Table 2.1 : Number of Specimens and Ages for each Test.

Specimens	Testing Age (Days)			
	3	7	14	28
MS (0%)	3	3	3	3
MS (5%)	3	3	3	3
MS (10%)	3	3	3	3
MS (15%)	3	3	3	3
MS (20%)	3	3	3	3
MS (25%)	3	3	3	3

Mix Proportioning

Mix Proportioning by weight was used and the cement/ dried total aggregates ratio was 1: 2: 4. Micro silica were used to replace OPC at dosage levels of 5%, 10%, 15%, 20% and 25% by weight of the binder. The mix proportions were calculated and presented in table 2.2

Table 2.2 : Mix proportion for 30Mpa Concrete

Materials	Mix Proportion (Kg)					
	Control	MS 5%	MS 10%	MS 15%	MS 20%	MS 25%
Cement(Kg)	370.0	351.5	333.0	314.5	296.0	277.5
Micro silica (Kg)	0	18.5	37.0	55.5	74.0	92.5
Total Water (Ltr)	140	140	140	140	140	140
Fine Aggregate (Kg)	780	780	780	780	780	780
Coarse Aggregate (Kg)	1180	1180	1180	1180	1180	1180
MS432 (ltr)	4	4	4	4	4	4
W/C	0.38	0.38	0.38	0.38	0.38	0.38

c) Testing of Specimens

Compressive strength test were carried out at specified ages on the cubes. The consisted of the application of uniaxial compressive load on the cube until failure at which point the load require for failure of each cube was noted (Fig 2.2), prior to testing, the density of each cube was determined using standard procedures for density determinations.

Figure 2.2 : Compression machine

III. Results and Discussion

The results of the chemical analysis of cement and micro silica are shown in Table 3.1.

Table 3.1: Chemical Properties of Cement and Micro Silica

Chemical Composition (%)	Cementitious Materials (%)				
	OPC	Requirement	MS Characteristics	Specification Requirement	Result by % by Mass
SiO_2	20.31	-	SiO_2	% Min 85.0	89.5
Al_2O_3	4.81	-	Moisture Content	% Max 3.0	0.8
Fe_2O_3	2.98	-	Loss of Ignition 975C	% Max 6.0	2.0
			Carbon		
CaO	62.73	-	45 Micron	% Max 2.5	0.7
MgO	2.97	5.0 Max	45 Micron	% Max 10	0.3
SO_3	2.78	3.5 Max		% Max 10	0.3
Alkalis (Na_2O + 0.658K_2O)	0.69				
Loss of Ignition (LOI)			Bulk Density		
Insoluble Residue (IR)	1.75	3.0 Max		500 – 700 (Kg/m^3)	675
Tricalcium silicate (C_3S)	0.62	1.5 Max			
Dicalcium silicate (C_2S)	70.79	66.7 Min			
Tricalcium aluminate (C_3A)	70.79	66.7 Min			
CaO/SiO_2	7.70	3.5 Max			
Chloride					
	3.09	2.0 Min			
	0.048	0.10 Max			
Physical Properties					
Fineness (Blaine Air Permeability Test Cm^2/g)	3290	No Limit			
Soundness (mm)	1.0	10 Max			

Density of Cubes

Table 3.1 shows the average densities of cured cubes before they were subjected to compressive strength tests.

Table 3.2 : Density of Cubes at testing Ages

% MS Replacement	Density (g/cm3)			
	Control	3 Days	7 Days	28 Days
0	2.55	2.57	2.59	2.64
5	2.46	2.47	2.50	2.60
10	2.40	2.45	2.47	2.52
15	2.41	2.43	2.48	2.50
20	2.39	2.44	2.46	2.49
25	2.37	2.43	2.45	2.46

Table 3.3 : Compressive strength Test Result for varying Micro Silica Replacement Levels in Concrete

%MS Replacement	Average Concrete Strength Mpa			
	3 Days	7 Days	14 Days	28 Days
0	26.32	30.55	36.07	40.55
5	28.11	33.11	40.77	44.44
10	30.57	38.26	44.72	48.75
15	29.19	34.59	42.58	45.17
20	28.02	31.40	36.25	41.53
25	26.39	30.85	36.20	40.90
% Increased	16.15%	29.24%	23.98%	20.22%

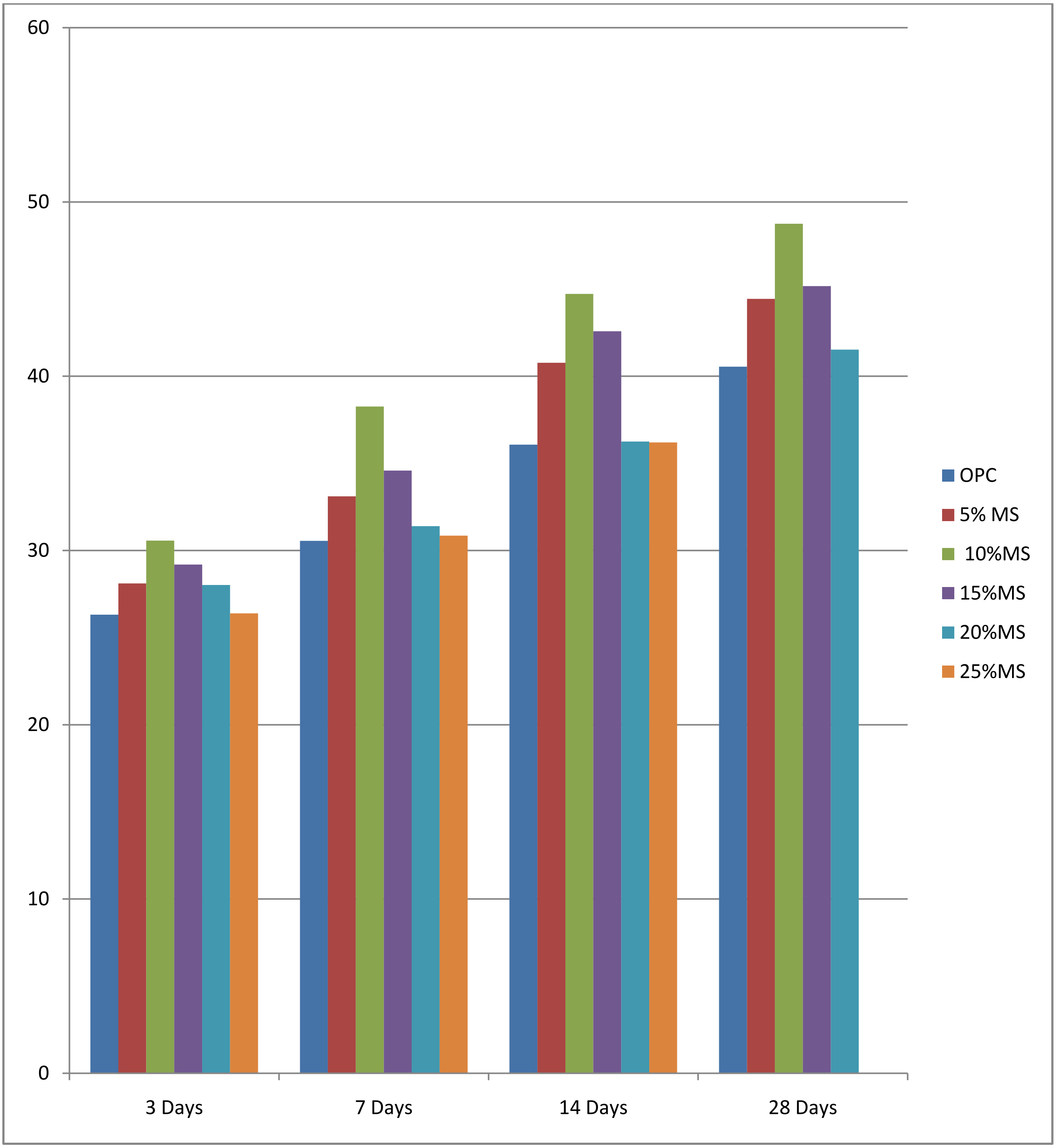

Figure 3.1 : Relationship between compressive strength of varying MS replacement levels.

a) Compressive Strength of Concrete

The test was carried out conforming to BS EN: 12390 – 3: 2009 to obtain compressive strength of C30 grade of concrete. The compressive strength of high strength concrete with OPC and silica fume concrete at the age of 3, 7, 14 and 28 days are presented in table 3.3.

There is a significant improvement in the strength of concrete because of the high pozzolanic nature of the micro silica and its void filling ability. The compressive strength of the mix C30 at 3, 7,14 and 28 days age, with replacement of cement by micro silica was increased gradually up to an optimum replacement level of 10% and then decreased. The maximum 3, 7, 14 and 28 days cube compressive strength of C30 grade with 10% of silica fume was 30.35, 38.26, 44.51, and 48.22 mpa respectively.

The compressive strength of C30 grade concrete with partial replacement of 10% cement by silica fume shows 15.31% greater than the controlled concrete. The maximum compressive strength of concrete with silica fume depends on three parameters, namely the replacement level, water cement ratio and chemical admixture. The superplasticiser admixture dosage plays a vital role in concrete to achieve the given workability at lower w/c ratio. Cement replacement up to 10% with micro silica leads to increase in compressive strength and beyond 10% to 25% there is a decrease in compressive strength for 3, 7, 14 and 28 days curing period.

It was observed that the percentage of micro silica replacement from average concrete strength (mpa) in table 3.3 were 16.15%, 29.24%, 23.98% and 20.22% for 3, 7, 14 and 28 days. The percentage given above shown that the compressive strength increased from 3 days to 7 days and decreased from 14 days to 28 days i.e. (23.98% to 20.22%). The maximum replacement level of silica fume is 10% for C30 grade

IV. Conclusions and Recommendations

- Cement replacement up to 10% with silica fume leads to increase in compressive strength, for C30 grade of concrete. From 15% there is a decrease in compressive strength for 3, 7, 14 and 28 days curing period.
- It was observed that the compressive strength of C30 grade of concrete is increased from 16.15% to 29.24% and decrease from 23.98% to 20.22%.
- The maximum replacement level of silica fume is 10% for C30 grade of concrete.
- Both the physical and chemical properties of micro silica and cement are in compliance with the standard except SO3 analyzed from cement.

Based on the conclusions arrived at, the following recommendations are made for future work:

- It is recommended that testing of concrete produced with micro silica concrete be extended to 56 or possibly 90 days to further determine the pozzolanic ability of the micro silica.
- Volume replacement methods are recommended to investigate the possibility of producing high strength concrete with micro silica.
- Detailed cost analysis should be carried out to determine the level of savings from the use of micro silica in concrete.

References Références Referencias

1. **Abdullah K. M, Hussin W, Zakaria F, Muhamad R, Abdul Hamid Z. (2006)** "POFA: A Pontential Partial Cement Replacement in Aerated Concrete" Proceedings of the 6th Asia- Pacific Structural Engineering and Construction Conference (APSEC 2006), 5-6 September 2006, Kuala Lumpur, Malaysia.
2. **Adepegba D. (1989)** " Pozzolanin Activity of Palm Bunch Wastes, Materials and Structures" Riaux et Constructions, 1989, 22,220-224.
3. **Bentur A. (2002),** Cementitious Materials – Nine Millennia and A New Century: Past, Present and future. Journal of Materials in Civil Engineering 2002: 14(1): 1-22.
4. **Bhanja S, Sengupta B.** Optimum silica fume content and its mode of action on concrete, ACI Materials Journal, September – October 2003, pp. 407 – 712.
5. **Coutinho SJ. (2003),** The combine benefit of CPF and RHA in improving the durability of concrete structures. Cement and Concrete Composites 2003: 25(1):5159. Gastaldine ALG, Isaia GC, Gomes NS, Sperb JEK.
6. **Hooten RD.** Influence of silica fume replacement of cement on physical properties and resistance to Sulphate attack, Freezing and Thawing, and alkli silica reactivity, ACI Material Journal, No. 2, 90(1993) 143 – 51.
7. **Igarashi S, Watanabe A, Kawamura M. (2005),** Evaluation of capillary pore size characteristics in high-strength concrete at early ages. Cement and Concrete Research 2005: 35(3): 513- 519.
8. **Olutoge FA. (2009):** Effect of Rice Husk Ash in the Production of Hollow Sandcrete Block. LAUTECH Journal of Engineering and Technology 5(1) 2009: 58-63.
9. **Sensale GR. (2006),** Strength development of concrete with rice husk ash. Cement and Concrete Composites 2006:28(2):158-160.
10. **Tiwari A, Momin I.** Improving early age strength of PSC with indigenous silica fume, The Indian Concrete Journal, October 2000, pp. 595 – 98
11. **Yogendran V, Langan BW, Haque MN, Ward MA.** Silica on high strength concrete, ACI Material Journal, No. 2, 84(1987) 124 – 9.

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Fracture properties of Self Compacting Concrete for Notched and Un-notched Beams

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Abstract - The aim of this research is to obtain the fracture characteristics of low and medium compressive strength notched and un-notched plain self compacting concrete (SCC) beams, using RILEM work of fracture (GF) methods and compare with those of normal concrete (NC) and high performance concrete (HPC), which is useful in engineering practice. The effect of notch-depth ratio on fracture characteristics of SCC beams, in bending is investigated by measuring the fracture energy (GF), critical stress intensity factor (KIC), critical energy release rate (Gc) and characteristic length (lch). The results show that: (i) GF increases with increase in compressive strength; (ii) The values of characteristic lengths of SCC (lch) are more when compared with HPC and NC and therefore may be concluded that the SCC with air-entraining admixture (AEA) is more ductile compared to HPC.

Keywords : Self compacting Concrete; Fracture Properties; Notched; Un-notched.

GJRE-E Classification : FOR Code: 090506

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Hamid Eskandari [α], S. Muralidhara [Ω], B.K. Raghu Prasad [β], B.V. Venkatarama Reddy [ψ]

Abstract - The aim of this research is to obtain the fracture characteristics of low and medium compressive strength notched and un-notched plain self compacting concrete **(SCC)** beams, using **RILEM** work of fracture **(G_F)** methods and compare with those of normal concrete **(NC)** and high performance concrete **(HPC)**, which is useful in engineering practice. The effect of notch-depth ratio on fracture characteristics of **SCC** beams, in bending is investigated by measuring the fracture energy **(G_F)**, critical stress intensity factor **(K_{IC})**, critical energy release rate **(Gc)** and characteristic length **(l_{ch})**. The results show that: (i) **GF** increases with increase in compressive strength; (ii) The values of characteristic lengths of **SCC (l_{ch})** are more when compared with **HPC** and **NC** and therefore may be concluded that the **SCC** with air-entraining admixture **(AEA)** is more ductile compared to **HPC**.

Keywords : Self compacting Concrete; Fracture Properties; Notched; Un-notched.

I. INTRODUCTION

Self-compacting concrete (SCC) is the current research area today. Many intrinsic properties of the concrete are yet to be understood clearly. The differences between High performance Concrete (HPC) and Self compacting concrete (SCC) are essentially in the use of special admixture [16]. Due to the use of chemical and mineral admixtures, the micro cracks study are more essential in SCC compared to NC [7,31].

Many investigators have evaluated the mechanical characteristics and durability of SCC mixes. The improved pore structure and better densification of matrix have bearing on the fracture characteristics like fracture energy (G_F) and critical stress intensity factor (K_{Ic}). It has been reported in literature that increased density will increase the compressive as well as tensile strength of concrete and also fracture energy [11]. Characteristic length (l_{ch}) will decrease with an increase in density [13].

Fracture behavior of plain concrete is the basis for all the studies on behavior of reinforced concrete (RC) and prestressed concrete structures via fracture mechanics. Experimental studies have been conducted to ascertain the effect of the aggregate on the fracture behavior of concrete. It is reported that an increase in the size of aggregate decreases the brittleness of hardened concrete and increases the fracture energy as well as fracture toughness [1,2,29].

Prokopski et al. [22] from their studies on the use of silica fume and effect of water-cement ratio on concrete have concluded that the stress intensity factor increases with addition of silica fume. The variations in stress intensity factor are closely related to the variation in the concrete matrix. Chen and Liu [6] have studied the effect of aggregate on fracture behavior of HPC and have shown that G_F and K_{IC} increase with increase in the aggregate size.

Planas and Elices [21] have shown that the fracture energy, G_F is size dependent. Ries and Ferreira [24] have studied the effect of specimen notch-depth on fracture energy and have shown that the specimen dimension do effect G_F and fracture energy increases with increase of notch to depth ratio, i.e. higher the notch to depth ratio, higher will be the fracture energy. Hence it has become a contentious topic in the fracture mechanics of concrete.

II. EVALUATION OF FRACTURE CHARACTERISTIC

a) Fracture energy (G_F) from work-of-fracture

Many methods have been recommended to determine the fracture energy and characteristic length, using simple three point bending tests (TPB) [17,19,20,30,4,10,18,12,9].

One can apply the recommendation of the Technical Committee RILEM [25] to perform three-point bend tests in notched beams. The Fracture energy is defined as the amount of energy necessary to create a crack of unit surface area projected in a plane parallel to the crack direction. As the beam is split in two halves, the fracture energy can be determined by dividing the total dissipated energy by the total surface area of the crack. According to the RILEM [26] to control the fracture energy can be calculated as

$$G_F = \frac{W_0 + 2mg\delta_0}{t(b-a)} \quad (1)$$

Where G_F = fracture energy (N/m), W_0 = area under the load-deection curve (Nm), m = weight of the beam between supports (kg), t = thickness; b = depth ;

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$\delta_0 =$ Displacement corresponding to P = 0 and a = initial notch of the beam.

i. *Intrinsic brittleness*

It is well known that the brittleness of concrete is characterized not only by the fracture toughness but also by a parameter related to it through other fracture and/or elastic constant. This parameter is a measure of the length of the fracture process zone. The smaller its value, the more brittle is the material. According to the fictitious crack model (FCM)[28], the brittleness can be expressed:

$$l_{ch}(mm) = EG_F/f_t^2 \quad (2)$$

Where E is modulus of elasticity in [MPa] and f_t is the tensile strength [MPa].

ii. *Fracture toughness*

The fracture toughness K_{IC} is calculated according to the RILEM [27] using the equation

$$K_{IC} = 3(P_0)\frac{S\sqrt{\pi}ag_1(\alpha)}{2b^2t} \quad [MPa\sqrt{m} \quad (3)$$

in which

$$g_1(\alpha) = \frac{1.99 - \alpha(1-\alpha)(2.15 - 3.93\alpha + 2.7\alpha^2)}{\sqrt{\pi}(1+2\alpha)(1-\alpha)^{3/2}} \quad (4)$$

where $\alpha = a / b$, P_0 = the measured maximum load [N] + self weight of the beam [N]. The result corresponds to the mean values of at least three tests. The critical energy release rate G_C is related to K_{IC} as:

$$G_C = (K_{IC})^2/E \quad (5)$$

III. Experimental Study

a) *Mix properties*

The cement used was 53 grade, having at 3, 7 and 28 days strength of 26.50, 33.20, and 53.40 MPa, respectively. Crushed granite aggregates of maximum size 16 mm were used. The specific gravity, dry-rodded unit weight, and water absorption of the coarse aggregate were 2.71, 1, 550 kg / m^3 and 0.5 by weight of the aggregate, respectively. River sand passing 4.75 mm was used. The specific gravity of the sand was 2.62 and the fineness modulus was 2.48. Class F fly ash from the thermal power plant near Raichur, India, was used. The CaO and loss on ignition (LOI) contents of y ash were 59, 1.02 and 1.08, respectively. The quantity of different materials for various mixes of SCC (SCC1, SCC2 and SCC3) are listed in (Table 1).

IV. Experimental Results

a) *Fresh properties of SCC*

The slump flow test is the most widely used method for evaluating concrete consistency in the laboratory and at construction sites. The consistency and workability were evaluated using the slump flow, U-Box, L-Box, J-Ring, V funnel and fill box tests.

The slump flow of SCC concrete was in the range of 650-750 mm, which is an indication of a good deformability. The time to reache 500 mm slump was in the range of 3-5 s, the J Ring was in the range of 3-8 mm, the funnel test flow time was in the range of 3-7 s, the funnel test flow after 5 minutes was in the range of 1-3 s, L-box, U box and Fill box were in the range of 0.8-1, 3-10 mm and 90-100% respectively. The fresh properties of SCC are summarized in (Table 2).

b) *Mechanical properties of scc*

Compressive strength, modulus of elasticity, exural strength and tensile splitting strength tests were conducted on all specimens of SCC mixes. The mechanical properties like compressive strength, exural strength, split tensile and modulus of elasticity of SCC were obtained testing 150 x 150 x 150 mm six cubes, 100 x 100 x 500 mm six prism and 150 x 300 mm cylinders the results are summarized in (Table 3).

The amount of powder usually cement +fly ash + microsilica used in SCC was in the range of 400-640 kg / m^3 for different grades of concrete. The density of SCC slightly decreased with decrease in the water-powder ratio. This may be due the combination of AEA and VMA which formed large amount of air pockets in concrete specimens. The compressive strength increased with the decrease in the percentage of y ash and water-powder ratio. The compressive strengths of SCC at 28 days varied from 15 to 45 MPa and increased by 10% at the end of 90 days.

The split tensile strength, exural strength and modulus of elasticity at the end of 28 days also showed reduction due to addition of y ash. This is because of the slower pozzolanic reaction of the mineral admixture, which caused slow rate of setting and hardening.

V. Analysis of Results

a) *Fracture Energy (G_F) from work-of-fracture*

In this category, the experiments were carried out using different mixes (SCC1, SCC2, and SCC3) with different sizes (440x100x100 and 850x100x100 mm) for notched and un-notched beams. Following two types of specimens were used: (i) un notched and (ii) notched with the ratio notch/depth equal to 0.5 and 0.1 for the spans of 400 and 800 mm respectively. Three-point bending tests were conducted using a closed loop Dartec Servo Controlled testing machine with a crack mouth opening rate of 0.001 mm/sec. The details of the concrete mixes labelled SCC1 to SCC3 for batches 1, 2, and 3, respectively, are given in Table 1. Before casting the beam specimens, a notch was introduced at the mid-section. It was 0.5 depth for the 800 mm beam and 0.1 depth for 400 mm span beam. The tests were controlled by the crack mouth opening displacement (CMOD). The complete load-deection and load-CMOD data were automatically stored on the computer. The (Figs. 1, 2 and 3) show the typical load-displacement and load-CMOD plot for SCC1, SCC2 and SCC3 with notched and un-notched respectively. In general, it is seen that as the notch to depth ratio increases, at peak load there is an increase in deection and CMOD.

From the (Figs. 1, 2 and 3), it is evident that; (i) the pre-peak stiffness of load-deection curve in the case of un-notched beams is more than that of notched beams. This is attributed to the presence of notch; (ii) there is a sudden drop after peak load in the load-deection curve in un-notched beam which highlights the brittleness induced to the absence of notch. However this is not observed in notched beam; (iii) the ratio of peak loads of notched and un-notched beams is about 0.25 which satisfies the strength of material theory.

Fracture energy, G_F is the energy needed to create a crack of unit area and also called as specific fracture energy. The work of fracture was calculated by measuring the area under the load-deection plot and the fracture energy was calculated from the (Eq. 1) as recommended in the RILEM guidelines and the values of G_F are given in (Table 4).

From the result of GF that is obtained by work of fracture, it is evident that the G_F is greatly affected by the size of beam and noth-depth ratio. Hillerborg [14] also showed that G_F increases with an increase in specimen size. The variability of G_F with specimen size and for its significant departure from G_c is mainly due to the violation of the two basic assumptions: (i) the work done by the external load goes solely into stable crack extension and (ii) the energy required to create a crack of unit area is independent of geometry and loading configuration. Several investigators have identified many processes, such as crushing of material, thermal loss, energy consumed in minor cracking, etc. other than the stable crack extension on which some energy is expended. Hence, it is clear that some errors are attributable to the determination of W_F and A_{lig}, which can explain the variability in G_F. It is also seen from the literature that for normal grade concrete, G_F varies from 40 to 130 N / m [15] and for the HPC it varies from 116 to 120 N / m [8]. From the present study, it is observed that GF for the notch/depth ratio 0.5 and span of 800 mm varies from 146 to 200 N / m and for un-notched beam varies 126 to 185 N / m. It can be seen that the fracture energy obtained with the span of 400 mm is slightly less than that of beam with span 800 mm. The value G_F of SCC in the present study is slightly more compared to that of normal concrete and HPC, this is due to the effect of porosity. SCC has higher porosity and less density compared to HPC and normal concrete.

Khalil Haidar [13] also has shown that the concrete becomes more ductile as the porosity increases (mass density decreases) and fracture energy is extremely dependent on the mass density of material.

Moreover, G_F is not constant but varies with the notch/depth ratio and G_F increase with an increase in depth of beam. (Fig. 4) shows the variation of fracture energy G_F with compressive strength. It is seen that the fracture energy increases with increase in strength as well as the increase in notch-depth ratio. As expected, the present work showed that the fracture energy, G_F, is a fracture parameter that is size-dependent [21,24]. It is found that G_F values show a definite trend to increase with increase of notch to depth i.e. un-notched depth has a lower value of G_F.

Fracture toughness (K_{IC}) is the value of critical stress intensity factor K, for which the crack starts growing. K_{IC} values for various mixes were obtained from a peak load based on LEFM approach (Eq. 3) and are given in (Table 5).

It is seen from the literature that the KIC values for various mixes varies from 0.8 to $MPa\sqrt{m}$ [23,3], while in the present study it varies from 0.58 to $0.74 MPa\sqrt{m}$ for notched beam and for un-notched varies from 0.24 to $0.31 MPa\sqrt{m}$ for the span of 800 mm length. It is observed from the (Table 5) and (Fig. 5) that with an increase in compressive strength of SCC, there is an increase in the fracture toughness for notch and un-notched beam. There is significant difference between K_{IC} of notched and un-notched beams. This is due to the presence of notch, which increases the ductility, when compared with an un-notched beam. It may be stated that in practice the beams are un-notched and hence the value of K_{IC} is over estimated.

For elastic brittle material $G_F = G_c$. However, for concrete, which is a quasi brittle material, G_F is higher than G_c because in the case of quasi-brittle materials there is stable crack growth before failure takes place. G_c normally varies between 3 to 20 N=m [15] for normal concrete and for HPC is varies between 17 to 40 N/m [5], while G_c varies between 18 to 20 N=m for notched beam and for un-notched beam varies between 2.9 to 3.2 N/m. The variation of K_{IC} is also reected in the corresponding toughness value G_c, since K_{IC}, and G_c are directly related as per (Eq. 5).

The characteristic length l_{ch} of SCC or brittleness of SCC based on FCM as per (Eq. 2) is given in (Table 5). Generally for normal concrete l_{ch} is about 200 to 500 mm [15,20] and for HPC it varies between 120-450 mm [23]. In SCC, l_{ch} varies from 580 to 740 mm for notched beams and varies between 540 to 640 mm for un-notched beams. It is also seen the l_{ch} decrease with an increase in compressive strength and notch-depth ratio.

VI. Conclusions

Experiments were conducted to determine the mechanical properties of SCC and fracture characteristic of SCC beams under three-point bend notched and un-notched beams were tested at the department of Civil

Engineering of the Indian Institute of Science in order to study the fractures properties of SCC. The main conclusions that can be drawn from this study are the following:

1. The results obtained by the work-of-fracture method follow the trend of "fracture energy increasing as the compressive strength of the concrete increases".
2. As expected, the present work shows that the fracture energy, G_F, is a fracture parameter that is size-dependent [21,24], i.e dependent on the specimen dimensions. It is found that G_F values show a definite trend to increase with increase of notch to depth i.e. 50 mm and 10 mm notch depth have a higher value of G_F compared to that of an un-notched beam. The size dependence is mainly due to irrecoverable damages outside the cracking plane which tends to increase with the specimen size.
3. The range of brittleness numbers found in this study shows that SCC is more ductile than HPC. Hence can be used at least for large size structures.
4. The values of characteristic length of SCC (l_{ch}) is to be more when compared with HPC, NC and high strength concrete. It may be concluded that the SCC is more ductile compared to HPC.

References Références Referencias

1. Amparano, F. E., Y. Xi, and Y.-S. Roh: 2000, `Experimental study on the effect of aggregate content on fracture behavior of concrete'. Eng Frac Mech 67(1), 65-84.
2. Appa Rao, G. and B. K. Raghu Prasad: 2002, `Fracture energy and softening behavior of high-strength concrete'. Cem Con Res 32(2), 247-252.
3. Bazant, Z. P. and E. B. Giraudon: 2002, `Statistical prediction of fracture parameters of concrete and implications for choice of testing standard'. Cem Con Res 32(4), 529-556.
4. [4] Belhamel, F., k. Hisham, and F. Kharchi: 2002, `Experimental method for the determination of the failure energy of ordinary concretes'. Mater Struct 35(3), 182-188.
5. Bharatkumar, B.: 2003, `Fracture characteristics and behaviour of high performance concrete (plain and reinforced)'. PhD thesis, IISc, India p. 235.
6. Chen, B. and J. Liu: 2004, `Effect of Aggregate on the Fracture Behavior of High Strength Concrete'. Constr Build Mater 18, 585-590.
7. Druta, C.: 2003, `Tensile strength and bonding characteristics of self-compacting concrete'. MSc thesis, Louisiana State Universityand p. 115.
8. Einsfeld, R. A. and M. S. Velasco: 2006, `Fracture parameters for High-performance concrete'. Cem Con Res 36, 576-583.
9. Elices, M., G. Guinea, and J. Planas: 1992, `Measurement of the fracture energy using three-point bend tests: Part 3-inuence of cutting the P-δ tail'. Mater Struct 25(4), 327-334.
10. [10] Elices, M., G. Guinea, and J. Planas: 1997, `On the measurement of concrete fracture energy using three-point bend tests'. Mater Struct 30(6), 375{376.
11. Giaccio, G., C. Rocco, and R. Zerbino: 1993, `The fracture energy (G_F) of high-strength conretes'. Mater Struct 26(161), 381-386.
12. Guinea, G., J. Planas, and M. Elices: 1992, `Measurement of the fracture energy using three-point bend tests: Part I-inuence of experimental procedures'. Mater Struct 25(4), 212-218.
13. Haidar, K. and G. P. Cabor: 2002, `Inuence of porosity on fracture characteristics in mortar structures'. Proc 15th ASCE Eng Mech, New York pp. 1-8.
14. Hillerborg, A.: 1985, `Results of three comparative test series for determining the fracture energy GF of concrete'. Mater Struct 18(107), 407-412.
15. Karihaloo, B.: 1995, `Fracture mechnaics and structural concrete'. Longman Scientific and technical,UK.
16. Kishi, T., A. Hosoda, C. B. Gurung, and S. Kittiwuttichusinp: 2000, `Effect of drying / autogenous shrinkage on ductility / fracture mode of beam and self-repairing function of expansive agent'. Pro JCI 22(3), 511-516.
17. Mindess, S.: 1984, `The effect of specimen size on the fracture energy of concrete'. Cem Con Res 14(3), 431-436.
18. NT Build 491: 1999, `Fracture energy (mode I)-three-point bend tests on notched beams'. Nordtest Method pp. 1{4. Available online, http://www.nordicinnovation.net/nordtest_ler/build491.pdf.
19. Petersson, P.: 1980a, `Fracture energy of concrete; method of determination'. Cem Con Res I0(1), 78-89.
20. Petersson, P.: 1980b, `Fracture energy of concrete: practical performance and experimental results'. Cem Con Res 10(1), 91-101.
21. Planas, J. and M. Elices: 1986, `Towards a measure of Gf: an analysis of experimental results'. Fracture Toughness and Fracture Energy of Concrete, Elsevier, Amsterdam pp. 381-390.
22. Prokopski, G. and B. Langier: 2000, `E_ect of Water/Cement Ratio and Silica fume Addition on the Fracture Toughness and Morphology of Fractured Surfaces of Gravel Concretes'. Cem Con Res 30, 1427-1433.
23. Raghu Prasad, B. K., B. H. Bharatkumar, D. S. R. Murthy, R. Narayanan, and S. Gopalakrishnan: 2005, `Fracture mechanics model for analysis of plain and reinforced high-performance concrete beams'. ASCE, Eng Mech J 131(8), 831-838.
24. Reis, J. and A. Ferreira: 2004, `A Contribution to the Study of the Fracture Energy of Polymer Concrete and Fibre Reinforced Polymer Concrete'. Polymer Testing 23, 437-440.

25. RILEM FMC-50: 1985, `Determination of the fracture energy of mortar and concrete by means of three-point bend tests on notched beams'. Mater Struct 18(4), 287-290.
26. RILEM FMT 89: 1990, `Size-effect method for determining fracture energy and process zone size of concrete'. Mater Struct 23(6), 461-465.
27. RILEM TC89-FMT: 1991, `Determination of fracture parameters (KIC and CTODc) of plain concrete using three-point bend tests'. Mater Struct 23(6), 457-460.
28. Shah, S., S. Swarts, and C. Ouyang: 1995, `Fracture Mechanics of Concrete - Applications of Fracture Mechanics to Concrete, Rock, and Other Quasi-Brittle Materials'. John Wiley & Sons, Inc., New York, USA p. 552p.
29. Strange, P. C. and A. H. Bryant: 1979, `The role of aggregate in the fracture of concrete'. J Mater Sci 14(8), 1863-1868.
30. Tang, T., C. Ouyang, and S. P. Shah: 1996, `Simple method for determining material fracture parameters from peak loads'. ACI, Mater J 93(2), 147-157.
31. Wittmann, F. H.: 2002, `Crack formation and fracture energy of normal and high strength concrete'. J Ind Nat Acad Sci 27(4), 413-423.

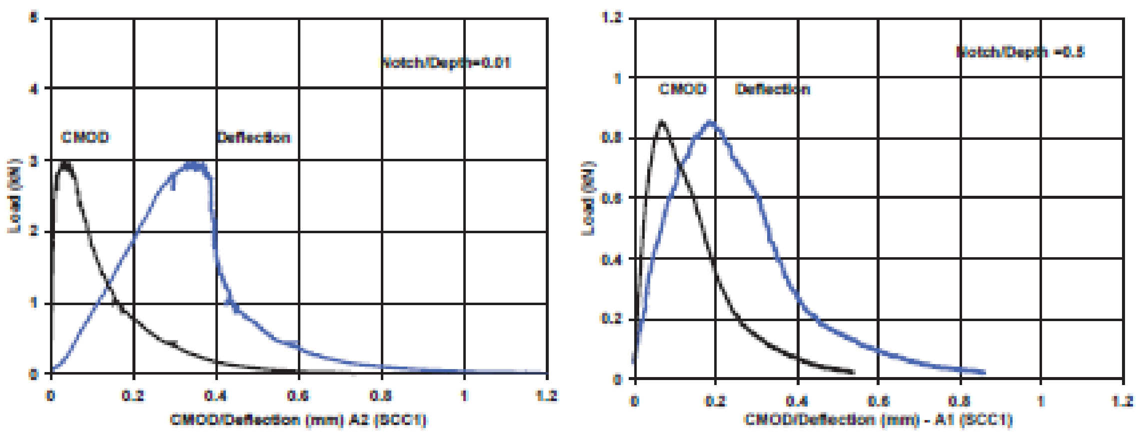

Fig. 1 : Typical load vs CMOD/Deection for mixes SCC1

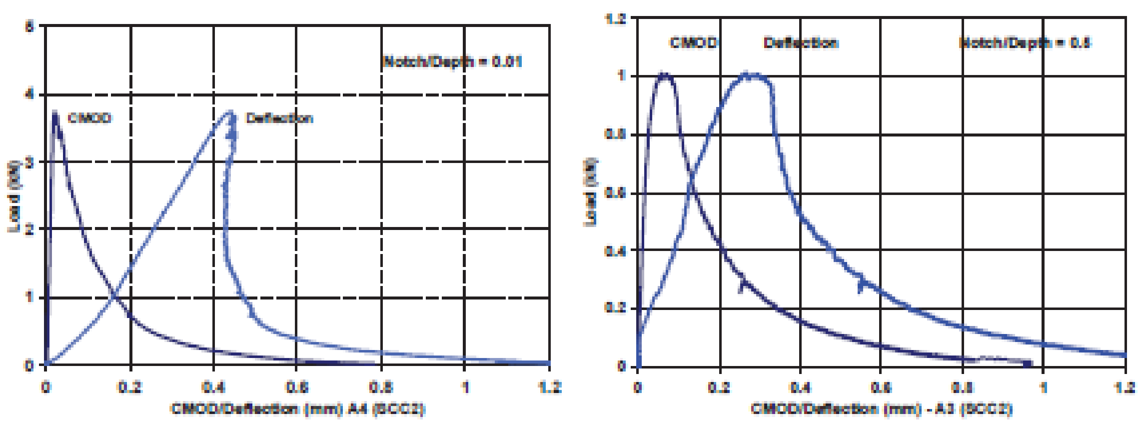

Fig. 2 : Typical load vs CMOD/Deection for mixes SCC2

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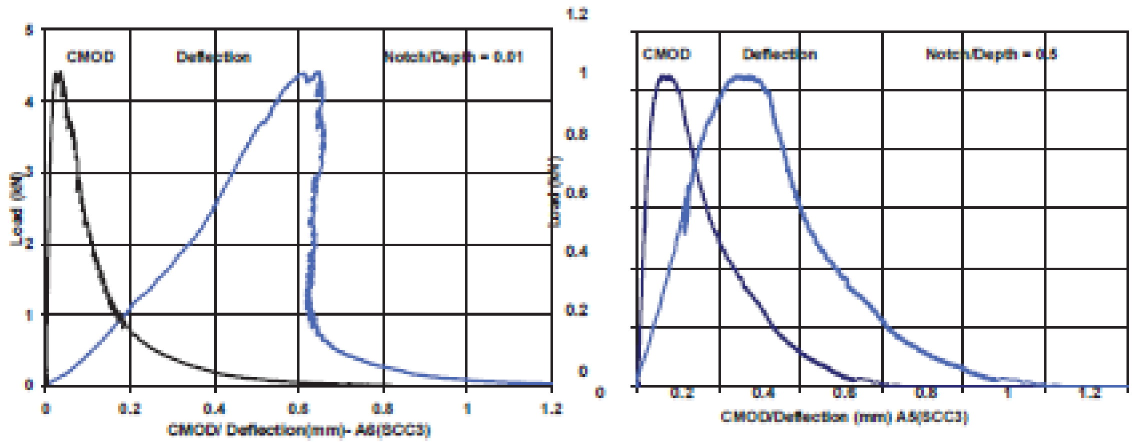

Fig. 3 : Typical load vs CMOD/Deection for mixes SCC3.

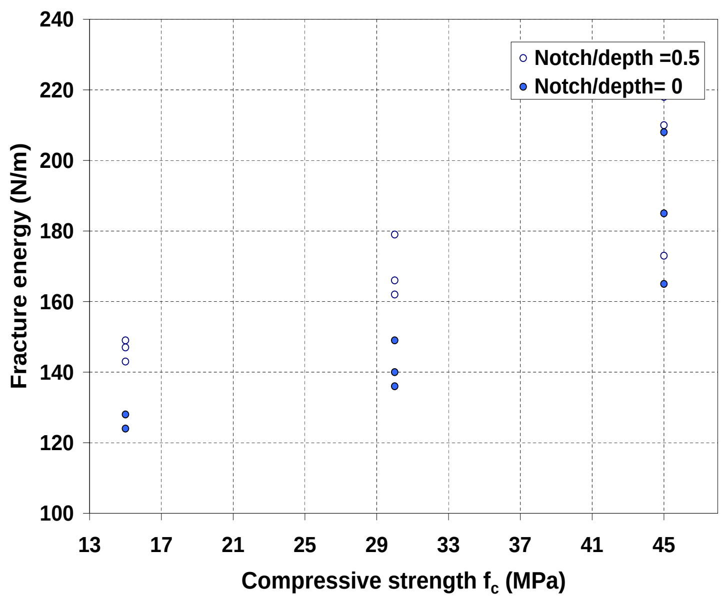

Fig. 4 : Fracture G_F vs compressive strength.

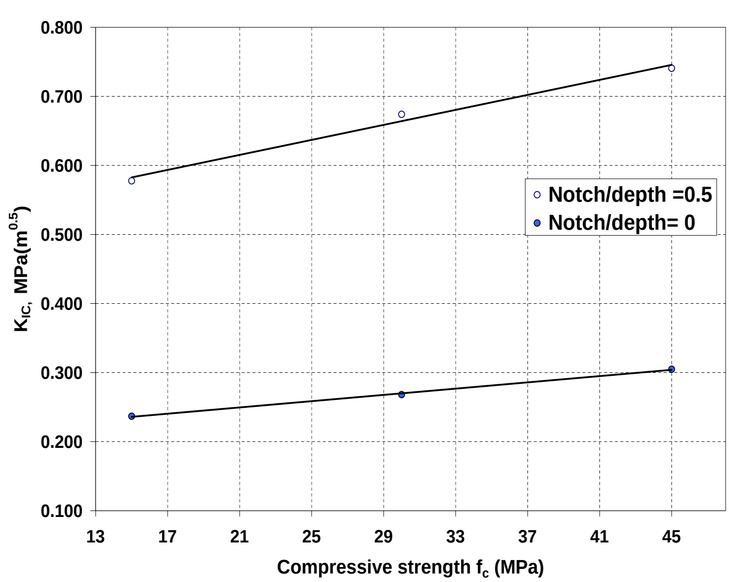

Fig. 5 : Critical stress intensity factor K_{IC} vs compressive strength.

Table 1 : Quantities of material for SCC kg / m3

Materials	SCC1	SCC2	SCC3
Cement (Kg)	240	400	360
Water (Kg)	220	180	190
Fine Agg. (Kg)	900	900	900
Coarse Agg. (Kg)	830	830	830
Fly ash (Kg)	184	200	196
Silica fume (Kg)	12	36	29
HRWR(liter)	2.00	4.00	3.50
AEA(liter)	0.20	0.24	0.40
VMA (liter)	0.50	1.50	1.25

Table 2 : Fresh properties of SCC

Tests	SCC1	SCC2	SCC3
Slump Flow (mm)	750	700	670
T50cm Slump Flow	3	4	5
J-ring (mm)	3.2	3	8
V-funnel (Sec)	4	6	7
V-funnel at T5	2	3	3
L-box $(H2/H1)$	0.8	1	0.95
U-box $(H2-H1)$	5	3	5
Fill-box(%)	95	95	95

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Table 3 : Mechanical properties of SCC

Mix	Density	f_c	E	f_t	f_r
	kg/m^3	MPa	GPa	MPa	MPa
	2044	17.1	17	1.5	2.6
SCC1	2074	16.8	17	1.8	2.7
	2074	16.1	16.5	1.7	3.0
	2006	29.8	21	2.7	4.2
SCC2	1956	30.4	22	2.7	4.2
	2010	31.4	22	2.7	4.2
	2163	45	28	3.4	6.2
SCC3	2133	46	28.2	3.4	6.3
	2104	43	27	3.4	5.9

Table 4 : Value of RILEM GF for SCC

Series	f_c	a/b	b	S	G_F (N/m) Beam			Average G_F
	(MPa)		mm	mm	1	2	3	(N/m)
A1 (SCC1)	15	0.5	100	800	143	149	147	146.3
A3 (SCC2)	30	0.5	100	800	162	179	166	169.0
A5(SCC3)	45	0.5	100	800	173	210	218	200.3
A7(SCC2)	30	0.1	100	400	122	148	N/A	135.0
A9 (SCC3)	45	0.1	100	400	165	185	216	188.7
HPC*	48	0.5	100	800	125	110	147	127.3
A2 (SCC1)	15	0.01	100	800	124	128	N/A	126.0
A4 (SCC2)	30	0.01	100	800	136	149	140	141.7
A6(SCC3)	45	0.01	100	800	165	185	207	185.7
A8 (SCC2)	30	0.01	100	400	117	130	116	121.0
A10(SCC3)	45	0.01	100	400	167	184	193	181.3

*Data from [8], N/A-No result available

Table 5 : Fracture characterize of SCC

Series	$Average$ $P_0(N)$	a/b	a mm	K_{IC} $MPa\sqrt{m}$	G_C N/m	l_{ch} mm
A1 (SCC1)	858	0.5	50	0.58	19.147	739.2
A3 (SCC2)	1001	0.5	50	0.67	18.428	603.7
A5(SCC3)	1100	0.5	50	0.74	18.170	584.3
A7(SCC2)	5570	0.1	10	0.6	57.784	482.2
A9 (SCC3)	5850	0.1	10	0.63	52.043	550.3
A2 (SCC1)	3200	0.01	1	0.24	3.218	636.5
A4 (SCC2)	3624	0.01	1	0.27	2.918	506.0
A6(SCC3)	4120	0.01	1	0.31	3.080	541.5
A8 (SCC2)	9893	0.01	1	0.37	21.748	432.2
A10(SCC3)	11672	0.01	1	0.43	24.718	528.9

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Engineering Performance of Concrete Beams Reinforced with GFRP Bars and Stainless steel

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Abstract - Corrosion of steel reinforcement is one of the main problems facing the construction industries throughout the world. Many methods have been used to minimize the problem but without success. Thus, more durable reinforcements are highly needed to replace conventional steel. Glass Fibre Reinforced Polymer (GFRP) bars provide a good alternative reinforcement due to its non-corrodible characteristic. This paper presents the flexural behaviour of concrete beams, each size is 150 x 150 x 900 mm and reinforced with GFRP and stainless steel bars. The behaviour of the beams was analysed in terms of their moment carrying capacity, load-deflection, cracking behavior and mode of failure. The experimental results show that beams reinforced with GFRP bars experienced lower ultimate load, lower stiffness, and larger deflection at the same load level compared with control beam. However, the performance of the SSRB (Stainless Steel Reinforced Beam) reinforced concrete beams improved slightly when compared to Glass Fibre Reinforced Polymer concrete beams.

Keywords : GFRP, Stainless Steel, Concrete Beams, Flexural Behaviour, crack width, failure mode.

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Strictly as per the compliance and regulations of:

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I. Introduction

The use of Fiber Reinforced Polymer (FRP) reinforcements in concrete structures has increased rapidly in the last 10 years due to their excellent corrosion resistance, high tensile strength, and good non-magnetization properties. However, the low modulus of elasticity of the FRP materials and their non-yielding characteristics results in large deflection and wide cracks in FRP reinforced concrete members. Consequently, in many cases, serviceability requirements may govern the design of such members. In particular, FRP rebar offers great potential for use in reinforced concrete construction under conditions in which conventional steel-reinforced concrete has yielded unacceptable service.If correctly applied in the infrastructure area, composites can result in significant benefits related to both overall cost and durability. Other advantages include high strength and stiffness to weight ratios, resistance to corrosion and chemical attack, controllable thermal expansion and damping characteristics, and electromagnetic neutrality. The FRP is made of continuous fibre filaments embedded in resin matrix to form various types of shapes such as bars, structural sections, plates, and fabric. There are three types of FRP materials commonly available in the market are Carbon Fibre Reinforced Polymer (CFRP), Aramid Fibre Reinforced Polymer (AFRP), and Glass Fibre Reinforced Polymer (GFRP). Saadatmanesh (1994). Studies the behavior of GFRP bar available in the market is manufactured in the same form and diameter as normal carbon steel. Compared with conventional steel the GFRP bars offer more benefits such as high tensile strength to weight ratio, corrosion free, lightweight, non-magnetic, and non-conductive. However, despite those benefits, the GFRP bars have low elastic modulus and behave elastically up to near failure (Clark, 1994). Osborne (1998) studied the emerging problem of steel corrosion in reinforced concrete structures leads to the development for more durable concrete and corrosion resistant reinforcement to be used for structures where the risk of corrosion is high. One of the method to enhance the durability of concrete is by the incorporation of pozzolanic materials such as slag, silica fume, and fly ash in the concrete mix. As for durable reinforcement, stainless steel is one of the options. However, the cost of stainless steel is very expensive compared to carbon steel. Therefore, the search for less expensive and more durable reinforcement continues.

Taerwe et al. (1999) conducted in the study ,in the last two decades, researchers explore the possibility of using Fibre Reinforced Polymer (FRP) materials to be used as concrete reinforcements. Fanning et al,(2001); Mohd.Sam et al.(1999 and 2002), studies have been conducted on the use of CFRP plate and fabric as strengthening material for reinforced concrete beams and columns.Abdul Rahman Mohd. Sam et al. (2003) paper presents the performance of concrete beams reinforced with different types of glass Fibre Reinforced Polymer (GFRP) sections. From their research it was made Comparison with a control beam on the aspect of ultimate load, load-deflection behaviour, load-reinforcement strain behaviour, and mode of failure. The experimental results show that beams reinforced with GFRP sections experienced lower load carrying capacity, lower stiffness, larger deflection and less number of cracks. The failure of the GFRP reinforced concrete beams was either by crushing of concrete at the compression zone or rupture of the GFRP reinforcement.Abdul Rahman Mohd. Sam et al. (2005) conducted a research work on replace conventional steel with GFRP bar. The research results show that beams reinforced with GFRP bars experienced lower ultimate load, lower stiffness, and larger deflection at the

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same load level compared with control beam. However, the performance of the GFRP reinforced concrete beams improved slightly when stainless steel mesh was used as shear reinforcement. Sungwoo Shin et al.(2009) had conducted an experimental work on strengthening of reinforced concrete structures using advanced fiber reinforced polymer (FRP) composites is a very popular practice because they are light and highly resistant to corrosion. The results of the investigation can be summarized as follows: (1) Deflections and strains of concrete beams reinforced with GFRP re-bars are generally larger than those reinforced with steel bars; (2) the strength of the concrete has a negligible effect on crack spacing and crack width; (3) and the FRP over-reinforced concrete beams in this study are safe for design in terms of deformability. Mohamed et al.(2011) investigated and evaluate the flexural behavior of concrete cantilever beams when using locally produced GFRP bars as a longitudinal main reinforcement. The experimental program includes six concrete cantilever beams. The main parameters were the type of rebars (steel or GFRP), strength of concrete and ratios of GFRP rebars. The results of experiments were the ultimate flexural capacities were calculated theoretically. Then a comparison between both experimental and theoretical results was done. This comparison indicated that the theoretical analysis gives results which are about 30% lower than the experimental ultimate flexural capacity for GFRP-reinforced cantilever beams. These two characteristics may affect the behaviour of concrete beams reinforced with such reinforcement, i.e. the stiffness and mode of failure. As from the structural point of view the stiffness is an important aspect to be considered since it affects the load carrying capacity of the member and the deflection at service load. This paper presents the suitability of GFRP bar and Stainless Steel bars to replace the conventional steel as the main tensile reinforcement. The short-term flexural behaviour of concrete beam reinforced with GFRP bar and Stainless steel bar was investigated. The behaviour of the GFRP reinforced concrete beam and Stainless steel reinforced concrete beam was also compared with Conventional concrete beam.

II. Research Significance

This paper presents the experimental results of testing concrete beams reinforced with GFRP bars and stainless steel bars under static loading conditions up to failure. This study investigates various behaviors including ultimate moment behavior, load-deflection pattern, crack width pattern and modes of failure. The behavior of concrete beams reinforced with GFRP bars is compared with the behavior of beams reinforced with stainless steel and conventional beam. This study focuses on the effects of concrete strength and the reinforcement ratio on the behavior of concrete beams. This study also aims to provide engineers and researchers with a better understanding of the behavior of GFRP-reinforced concrete beams and stainless steel reinforced concrete beams. The results obtained throughout this study are valuable for future field applications and the development of design guidelines for concrete elements reinforced with GFRP bars and stainless steel bars.

III. Experimental Work

The current research program was carried out to investigate the flexural behavior of concrete beams with main reinforcement of GFRP bars and stainless steel bars.

IV. Material Characteristics

Seven reinforced concrete beams were cast and tested to failure. The overall dimensions of the reinforced concrete beam tested were 150 x 150 x 900 mm. The control beam, RCCB, was reinforced with 2@12 mm diameter deformed. The others are three GFRP beam reinforced with 2@12 mm diameter of GFRP bars and remaining three of SSR beams were made in reinforced with 2@12 mm diameter of Stainless steel bars. The shear reinforcement for beams GFRP and SSR was provided using a GFRP-10 mm diameter and Stainless steel plain10 mm diameter bar. All of the beams tested were designed to fail in flexure. The concrete with an average strength of 30 MPa at 28 days was used throughout the study. The compositions of the concrete consisted of ordinary Portland cement, coarse aggregate and natural river sand. The coarse aggregate used in concrete mix was a combination of crushed and uncrushed gravel with the nominal diameter of 20 mm. The water-cementations ratio used was 0.50.All of the beams were cast in steel moulds and manufactured in the laboratory. The beams and cubes were cured in good water available in the laboratory at room temperature.

V. Test Setup and Test Procedure

The simply supported beam with the effective span of 800 mm was tested under four-point loads at the age of 28 days up to failure. The two-point loads were applied in the middle of the beam at a distance of 267 mm apart. The schematic diagram of the beam and test setup is shown in Figure 1 and Figure 2. The load is monotonically applied during testing in a 400 kN U.T.M (Universal Test Machine). Deflection of the tested beams is measured with a deflectometer at mid-span. During testing, cracks are marked and crack width is measured using a hand-held microscope. Crack spacing is measured within the constant moment zone. Deflections, ultimate capacities, and failure modes are also investigated.

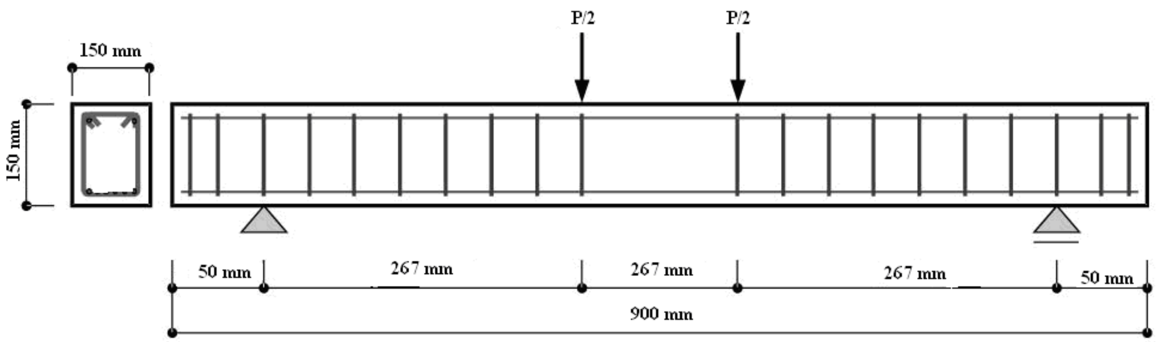

Figure 1 : Schematic diagram of the test set-up

*Figure 2 :*Test setup

VI. Results and Discussion

a) General Behavior

The steel reinforced control beams (RCCB) develop flexural cracks at mid-span after the first crack, flexural cracks are uniformly distributed throughout the tension zone. Following yielding of the steel bars, beam deflections increase without an increase in load. A ductile flexural failure occurs with yielding of the reinforcing steel. The amount of energy absorbed through plastic deformation in the reinforcement demonstrates the advantage of steel as a reinforcing agent. The behavior of the FRP reinforced beams differs from that of the steel reinforced beam. Final failure occurs in two distinctly different modes, as shown in Figure 4.The first mode is the FRP rupture of the under-reinforced beams. Tensile rupture of the GFRP bar occurs in all beams that are reinforced with lower balanced reinforcement ratios. These results demonstrate the brittleness of FRP materials. The second mode of failure is the crushing of concrete in the over-reinforced beams. As expected, the failure in beams reinforced with more than the balanced reinforcement is due to the compressive failure of concrete crushing. Observed cracks within and near the constant moment region expand in a vertical direction. As the load increases, shear stress become more critical and induces inclined cracks. Table 2. shows the average crack spacing in tested beams at service load and high load. The effect of the concrete strength and the reinforcement ratio on the crack spacing is negligible, and the crack spacing decreases as the load increases.

b) Load-Deflection Behaviour

The short-term load-deflection behaviour of all the beams tested is shown in Figure 3. Initially all beams show relatively linear elastic behaviour up to the cracking load when the concrete cracked at the tension face. Thereafter, the stiffness of the beams, particularly for the GFRP reinforced concrete beams, was reduced at a faster rate, resulting in a larger deflection. This may be due to the effect of low elastic modulus of the GFRP bar compared to stainless steel.

Comparing the deflection between beams GFRP and RCCB the former had, for a given load, larger deflection in the order of 1.75 to 2.0 times the deflection of the control beam (RCCB).The average measured deflections at near failure for beams GFRP and RCCB were 14.5 mm and 8.2 mm, respectively. This indicates that direct replacement of steel with GFRP bars, on the basis of the same area of reinforcement replacement, will not produce the same performance as beam reinforced with steel. Therefore, some modification in the design has to be considered when GFRP bar is to be used as reinforcement.

The use of stainless steel as reinforcement in beam (SSRB) resulted increased deflection on same load was observed when compared to glass fiber reinforced concrete beam (GFRPB) and control beam(RCCB) also in slight improvement on the stiffness of the beam were observed. The deflection ratios, at the same load level, between beams SSRB and RCCB were in the range of 1.75 to 2.15 which show slight only slight difference as compared with the GFRPB beam. The deflection of the beam near to failure was 18.5 mm. This indicates that the use of stainless steel as reinforcement not only provides reinforcement to resist load but also increase, to some extent, the stiffness of the beam.

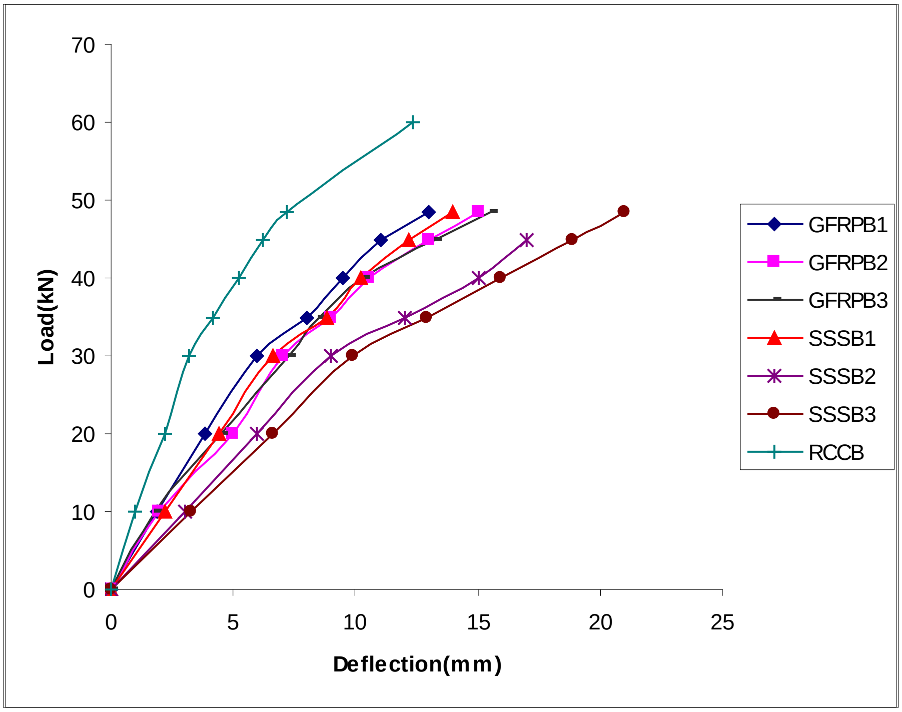

Figure 3 : Load-deflection of tested beams

c) Ultimate moment at Failure

The ultimate failure moment of all the tested beams are presented in Table 1.From the Table1 it was observed that the control beam(RCCCB), had higher load carrying capacity compared to the GFRP reinforced concrete beam, by about 30% .This shows that the low elastic modulus of the GFRP bar had an effect on the load carrying capacity of the beam.

As for beam SSRB, the use of stainless steel as reinforcement has improved, to some extent, the ultimate failure moment of the stainless steel reinforced concrete beam (SSRB) by about 12% compared to beam GFRPB. This was due to the effectiveness of stainless steel as shear reinforcement.

Table1 : Comparison between experimental and theoretical ultimate moments

Beam No.	Experimental Ultimate moment(kN m)	Theoretical design moment (kN m)	Capacity ratio
GFRPB1	4.00	6.50	0.62
GFRPB2	4.21	6.50	0.65
GFRPB3	4.10	6.50	0.63
SSRB1	4.60	6.50	0.71
SSRB2	5.06	6.50	0.78
SSRB3	5.20	6.50	0.80
RCCB	6.00	6.50	0.92

d) Cracking and mode of failure

All of the tested beams failed in flexure with crushing of concrete in the compression zone at the failure stage after the development of flexural cracks. The failure mode and crack pattern of the tested beams are presented in Figure 4.From Table 2 it was observed that all of the beams cracked in tension under a relatively small load of about 7.5% to 11% of their ultimate load. The first visible crack formed between the locations of the two point loads in the region of maximum bending moment. Thereafter, as the load was increased more cracks started to form over the shear span on both sides of the beam.

Beam GFRPB recorded about 25% less number of cracks and more crack spacing by about 40% compared with the control beam(RCCB). This may indicate that the stiffness of the GFRP bar had an effect on the cracking behaviour of the beam. In compare to the control beam and stainless steel reinforced beam (SSSRB), experienced greater number of cracks with smaller crack spacing. The average crack spacing for beam B3GM was about 20% less than the control beam. Thus, it shows that stainless steel can be used to reduce the cracking of the reinforced concrete beam.

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Table 2 : Cracking behaviour of Steel slag concrete beam

Beam No.	Ultimate Load(kN)	First Crack Load(kN)	Total Number of Cracks	Average Crack Spacing(mm)
GFRPB1	34.00	4.00	20	130
GFRPB2	36.00	4.50	25	140
GFRPB3	35.00	4.00	23	150
SSRB1	40.00	3.50	25	130
SSRB2	44.00	4.00	24	140
SSRB3	45.00	4.25	23	160
RCCB	52.00	7.00	25	100

Figure 4 : Mode of failure and crack pattern of all the beams tested

VII. Conclusions

The main conclusions that can be drawn from this study are as follows:

1. Concrete beam reinforced with GFRP sections experienced lower load carrying Capacity and stiffness compared with the conventional reinforced concrete beam(RCCB).
2. Beam reinforced with GFRP bars showed different flexural behavior than that of beam reinforced with stainless steel bars this was mainly due to the lower elastic modulus of the GFRP section.
3. The number of cracks for beam reinforced with GFRP section was lower than the conventional beam. In addition, the average crack spacing of the GFRP reinforced concrete beam was also larger compared with the control beam.
4. In addition, the deflections in beams reinforced with GFRP bars are generally larger than those in beams reinforced with steel bars. This is due to the low modulus of elasticity and the different bond characteristics of the GFRP bars. To ensure adequate flexural stiffness for deflection, the flexural design of FRP reinforced concrete beams requires over-reinforcement.
5. The mode of failure for beams reinforced with GFRP sections were slightly different compared with the control beam(RCCB). The GFRP reinforced concrete beams will fail either by concrete crushing at the compression zone or rupture of the GFRP reinforcement. Failure due to rupture of GFRP reinforcement is not recommended because it may results in catastrophic failure of the structures.
6. The use of stainless steel reinforcement beam proved to be beneficial in enhancing the stiffness, ultimate load, and cracking performance of the GFRP reinforced concrete beam.
7. Considerations on the elastic modulus and proper design method are important when GFRP bars are to be used as tensile reinforcement for concrete beam.

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Notations

RCCB : Reinforced Cement Concrete Beam

GFRPB : Glass Fibre Reinforced Polymer Beam

SSRB : Stainless Steel Reinforced Beam

References Références Referencias

1. Abdul Rahman Mohd. Sam, Shukur Abu Hassan, Tan Sim Thye, (2003), "Glass FibreReinforce Polymer Structural Selection as Concrete Beam Reinforcement ", Jurnal Kejuruteraan Awam, Vol.15(1): pp. 16-23.
2. Abdul Rahman Mohd.Sam, Narayan Swamy R ,(2005), "Flexural Behaviour of Concrete Beams Reinforced with Glass Fibre Reinforced Polymer Bars", Jurnal Kejuruteraan Awam , Vol. 17(1), pp. 49-57.
3. Clark, J. L. (1994) Fibre composites for the reinforcement of concrete. In F. K. Garas, G.S. T. Armer and J. L. Clark (eds.) Building the Future-Innovation in Design,Materials and Construction,, E&FN SPON, London, pp. 183-191.
4. Fanning, P. J., and Kelly, O. (2001) Ultimate response of RC beams strengthened with CFRP plates. Journal of Composite for Construction, 5(2): 122-127.
5. Mohd.Sam, A.R. (1999) Flexural Behaviour and Durability of Glass Fibre Reinforced Polymer and Stainless Steel Bars as Beam Reinforcement. PhD Thesis, University of Sheffield, U.K, 304 pp.
6. Mohd.Sam, A.R., Abu Hassan, S. and Cheong, C. H. (2002) The flexural behaviour of reinforced concrete beams strengthened with CFRP plates. Proc. of the Research Seminar on Materials and Construction, Universiti Teknologi Malaysia, Johor, pp. 49-55.
7. Mohamed S. Issa and S. M. Elzeiny, (2011), Flexural behavior of cantilever concrete beams reinforced with glass fiber reinforced polymers (GFRP)bars, Journal of Civil Engineering and Construction Technology ,Vol. 2 ,No.2, pp. 33-44.
8. Osborne, G. J. (1998) Durability of Portland Blastfurnace Cement. Joe G. Cabrera Symposium on Durability of Concrete Materials. Ed. Swamy, R.N., 79-99.
9. Saadatmanesh, H., (1994) Fibre composites for new and existing structures. ACI Structural Journal, 91(3): 346-354.
10. Sungwoo Shin, Daewon Seo and Byumseok Han ,(2009), "Performance of Concrete Beams Reinforced with GFRP Bars", Journal of Asian Architecture and Building Engineering (JAABE), vol.8, No.1, pp.197-204.
11. Taerwe, L. R., and Matthys, S. (1999) FRP for concrete construction. Concrete International, 21(10): 33-36.

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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
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