ISSN: 2394-2827

International Journal of Advances in Mechanical and Civil Engineering

Volume No. 12
Issue No. 2
May- August 2025

ENRICHED PUBLICATIONS PVT.LTD

JE - 18,Gupta Colony, Khirki Extn,
Malviya Nagar, New Delhi - 110017.
E- Mail: info@enrichedpublication.com
Phone :- +91-8877340707

ISSN: 2394-2827

International Journal of Advances in Mechanical and Civil Engineering

Aim & Scope

International Journal of Advances in Mechanical and Civil Engineering(IJAMCE) is a scholarly online, open access, peer-reviewed, interdisciplinary and fully refereed journal focusing on theories, methods and applications in Mechanical Engineering and Civil Engineering . It is an international scientific journal that aims to contribute to the constant scientific research and training, so as to promote research in the field of Mechanical and Civil Engineering.

ISSN: 2394-2827

Editor-in-Chief

Associate Editor

ISSN: 2394-2827

International Journal of Advances in Mechanical and Civil Engineering

(Volume No. 12, Issue No. 2, May- August 2025)

Contents

ISSN: 2394-2827

LABORATORY INVESTIGATION ON EVOLVING THE MIX DESIGN OF RCC CONTAINING RAP AGGREGATES AND SILICA FUME

1SHASHI KANT SHARMA, 2PRANAV SHARMA

1,2Civil Engineering Department, Dr B R Ambedkar National Institute of Technology, Jalandhar, India

ABSTRACT

India has one of the largest road networks in the world. Regular maintenance and rehabilitation of asphalt pavements that comprise 80-90% of this network generate a huge amount of Reclaimed Asphalt Pavement (RAP) aggregates, which lead to stockpiling causing negative effects on the environment. Reconstructing asphalt pavement with RAP is easy but it requires additional asphalt addition, which is quite costly. The use of RAP in pavement quality concrete (PQC) is not conducive due to reduced bonding with cement paste. Roller compacted concrete (RCC) offers an alternative as its strength also depends upon the friction between the constituting particles thereby reducing cement demand, and it is stiff enough to support the compaction under roller load. This study investigates the feasibility of using RAP aggregates in the RCC and PQC mix. The evolution of the RCC mix was initiated from a reference PQC mix designed as per IRC: 44-2017. Combined coarse and fine aggregates were replaced by 50% coarse & fine RAP aggregates by volume in PQC and mixtures. Results showed that RAP addition leads to a reduction of compressive & flexural strength in PQC and RCC mixes by 24% & 20% and 24% & 14%, respectively. Silica fume addition (15% by volume of cement) improved the compressive & flexure tensile strength of the RCC-RAP mix such that these values (32.8 MPa & 3.9 MPa) are just 29% lesser than the PQC mix, though the mix qualifies the strength criteria of an RCC, thus encouraging RCC-RAP usage along with silica fume in rigid pavement construction. Advantages of RCC, such as roller compaction, lesser cement requirement, use of waste materials like RAP and SCMs, and early traffic opening certainly make it a sustainable concrete.

Keywords *- Reclaimed Asphalt Pavement (RAP), Pavement quality concrete (PQC), Roller compacted concrete (RCC),*

I. INTRODUCTION

The development of a country and civilization depends upon the connectivity of various places with adequate roads. For the construction of roads, two types of methodologies are adopted based on different structural abilities to sustain load by a mechanism of load transfer from particle to particle in flexible pavements and slab action in rigid pavements. Due to the scarcity of fossil fuels and petroleum products and the lower strength & durability of asphalt pavements, the Ministry of Road Transport and Highways in India is encouraging the construction of concrete pavement owing to its superior structural and durability properties over flexible pavements [1].

The most preferred type of rigid pavement is Pavement Quality Concrete (PQC) whose surface course is prepared by joining precast concrete slabs or cast in situ with or without steel reinforcement. The basic components of PQC are cement, aggregates, and water. For producing 1m3 of PQC of M 40 grade, roughly the cement content ranges from 400-450 kg/m3 and comprises 70-75% of aggregates [2]–[4] The use of such an amount of aggregates is making us loose on our bank of natural aggregates, thereby motivating the researchers to explore for feasible replacement options. One such solution to the problem can be to replace natural aggregates with recycled aggregates such as Reclaimed Asphalt Pavement (RAP) aggregates. Approximately 90% of road pavements in India being flexible pavements, which generate about 100 million tons (at par with the USA) of reclaimed asphalt pavement (RAP) per year through various reconstruction and rehabilitation processes [5]. Some of it is reutilized for recycling in new asphalt mixtures but still, large quantities of RAP is left unutilized which causes dumping issues and leads to stockpiling problem. Utilizing these aggregates obtained by demolishing, milling, or fully reclaiming the asphalt pavement can be very crucial and beneficial in terms of reducing the demand for natural aggregates and their sustenance, curtailing production energy (carbon footprint reduction), transportation cost along with effective waste utilization making the project economical as well as eco-friendly. The potential use of RAP in forms like coarse RAP (CRAP), fine RAP (FRAP), and a combination of both (RAP) in pavement concrete mixes resulted in a decrease in strength due to the formation of weaker ITZ because of the presence of asphalt layer around RAP aggregates [1], [4], [6]–[8], [10]. The utilization of 100% RAP can reduce the strength up to 60 to 80% [4], [7]. The addition of CRAP by 50% and 100% can reduce the strength by about 15-35% [1], [10] and 20-40% [8], [9] respectively. Further, the addition of FRAP by 50% and 100% can reduce the strength by about 15% [1], [4] and 30-50% [4], [8], [9] respectively. However, the mix containing CRAP aggregates performs better than FRAP and total RAP incorporated mixes [1], [7]. The reductions in flexural strength are lower than the reduction in compressive strength [6], [10]. This was due to the visco-elastic nature of asphalt film which induces a failure of ductile nature and enhances toughness properties [6], [8], [10].

Although, the presence of high cement content in PQC results in superior strength durability properties but in most instances also leads to a major problem of high shrinkage in slabs ranging from 350 – 400 μm/m at 90 days which could be negated by providing joints [6], [7]. In PQC, the traffic is opened after 28 days of curing to achieve sufficient strength development. In search of overcoming these shortcomings, Roller Compacted Concrete (RCC) has emerged as an alternative option. RCC is typically a stiff and dry concrete paved by asphalt pavers and compacted by roller, having lower cement content and a higher proportion of fine aggregates as compared to PQC, yet it is optimally wet enough to ensure even distribution of cement paste. According to ACI guidelines, the RCC mix should be able to achieve a minimum compressive strength and flexural strength of 27.6 MPa and 3.67 MPa respectively at 28 days of curing to be used in the surface layer of pavements [11]. The driving force of strength development in PQC is mainly cement hydration but in the case of RCC in addition to cement hydration, the majority of strength development is due to friction amongst interlocked particles of the concrete matrix that plays important role in early age strength induction, giving opportunity for early traffic opening on RCC pavements. In RCC, for optimum moisture content, the process of compaction can minimize the voids by forcing the aggregates to push against each other resulting in maximum density. This moisture content generally ranges from 4-7% [12], which for pavement application is determined by trials using the Soil Compaction Method. The denser concrete matrix and relatively lower cement content help in reducing the shrinkage problem with the shrinkage strains being about 50% of that observed in PQC [9]. With no joints, reinforcement & formwork requirements in RCC and a simple construction methodology of paving and rolling over concrete saves time as well as is economical. As

the primary source of strength induction in the case of RCC is due to friction amongst particles, it exhibits scope for use of waste materials as replacements for aggregates and cement which can be beneficial for sustainable construction. The utilization of RAP in RCC can be a prominent aspect as the RAP aggregates obtained after milling are generally angular, which can be beneficial in interlocking amongst concrete matrices. The replacement of aggregates in RCC mixes by CRAP, FRAP, and combined RAP mostly decreased the strength due to inferior ITZ formation due to the presence of the asphalt layer [13]–[19]. The utilisation of 100% RAP and 50% RAP can reduce the strength up to 38-63% [13], [14], [16], [18] and 21-50% [13], [16], [19]. The addition of CRAP by 50% and 100% can reduce the strength by about 24% and 25-52% respectively [13], [14], [16]. Further, the addition of FRAP by 50% and 100% can reduce the strength by about 11% [16] and 16-37% [13], [14], [16] respectively. However, the mix containing CRAP aggregates performs better than FRAP and total RAP incorporated mixes [14]. On contrary, FRAP mixes yielded better results as compared to CRAP RCC mixes due to the presence of dust contaminants in fine RAP making it well-graded [13], [16], [17]. The reductions in flexural strength are less pronounced than the reduction in compressive strength [16], [17]. This was due to the crack arresting nature of asphalt film which induces ductility and enhances toughness properties [16], [17]. For RAP incorporated RCC mixes the replacement of up to 50% is reported to be suitablefor use in pavement applications achieving ACI standards [13], [16], [18]. Some common inconsistencies were found in the related studies. Firstly, the development of RCC mixes is based on the trial and error method without describing much about the composition of materials used for the preparation of RCC mixes. Secondly, for the replacement of natural aggregates with RAP aggregates, the gradation of the two is not complimenting in nature, with the RAP being used without checking its gradation, which in most studies for both PQC and RCC do not conform to standard gradation guidelines.

To investigate the above-mentioned inconsistencies, this study attempts to develop a mix design methodology for RCC relating it to the mix design of PQC which is obtained as per standard guidelines of IRC: 44-2017 [20]. Further to investigate the effects of using standardized aggregate gradation for RAP, replacement of both fine and coarse aggregates is done by 50% RAP aggregates by volume in both PQC and RCC mix, while following the aggregate gradations of both natural as well as RAP aggregates conforming to IRC: 44-2017 & IRC-SP: 68-2005 [12] for PQC & RCC respectively. Further, 15% of cement by volume is replaced by silica fume (SF) in RAP incorporated RCC mix.

II. MATERIALS & METHODOLOGY

2.1. Materials

The coarse (NCA) and fine (NFA) aggregates of nominal size 20 mm and 4.75 mm passing, Zone II respectively were obtained from crushed rock and river sand from Jalandhar, India which followed IS 383-2016 [21] & IRC 44-2017 specifications. The RAP aggregates are obtained from the milling operation of bitumen pavement of service road of GT Road, Jalandhar, India. The milled RAP aggregates are further screened and sieved into different sizes with aggregates of flaky and elongated nature discarded off. The aggregates passing through a 4.75 mm sieve were taken as Fine RAP (FRAP) and gradation of coarse RAP (CRAP) was formed similar to 20 mm nominal size.

A comparison of properties of aggregates is shown in Table.1. & Table.2.

Properties	NCA	CRAP
Specific Gravity	2.56	2.44
Water Absorption	0.95%	0.78%
Impact Value	10.4%	16%
Crushing Value	12.08%	13.12%
Abrasion Value	9.06%	21.5%
Bitumen Content	-	4.8%

Table.1. Comparative Properties of coarse aggregates and Coarse RAP aggregates

Properties	NFA	FRAP
Specific Gravity	2.48	1.98
Water Absorption	1.65 %	2.83%
Fineness Modulus	2.53(Zone 2)	2.90(Zone 2)
Bitumen Content	-	6.3 %

Table.2. Comparative Properties of fine aggregates and Fine RAP aggregates

The cement used in the study is of OPC 43 grade having a specific gravity of 3.15 conforming to IS 8112 -2013 [22]. Silica Fume (SF) having specific 2.2 obtained from M/s Elkem Materials Inc., India is used. The water used throughout the study is potable and drinking water free from the effect of any hazardous contaminants. All the respective materials used in the study are shown in Fig.1. & Fig.2.

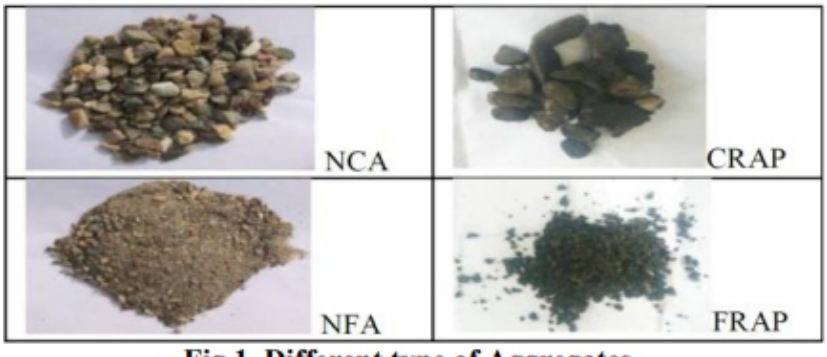


Fig.1. Different type of Aggregates

Fig.2. Cementitious materials

The combined aggregate gradations of natural aggregates (NA) and aggregates comprising 50% RAP aggregates (RAP) for PQC mixes conformed to the combined aggregate gradations for 20 mm nominal size of aggregates specified in IS 383-2016 & IRC 44-2017. While for RCC mixes, these combined aggregate gradations confirmed to combined aggregate specifications of IRC: SP-68. The gradations of combined aggregates (20mm nominal size) used in this study are shown in Fig.3. & Fig.4. with upper limit (UL) and lower limit (LL) demarcated as per respective code specifications.

2.2. Methodology

Mix design of Pavement Quality Concrete (PQC) is performed as per the specifications of IRC 44-2017 with 4.5 MPa as the target flexural strength. This control mix (PQC) had natural aggregates, with a cement content of 410 kg/m3 (about 13% by volume), sand to aggregate (S/A) ratio of about 0.45 by volume, and a w/cm (water to cementitious material ratio) of 0.36.

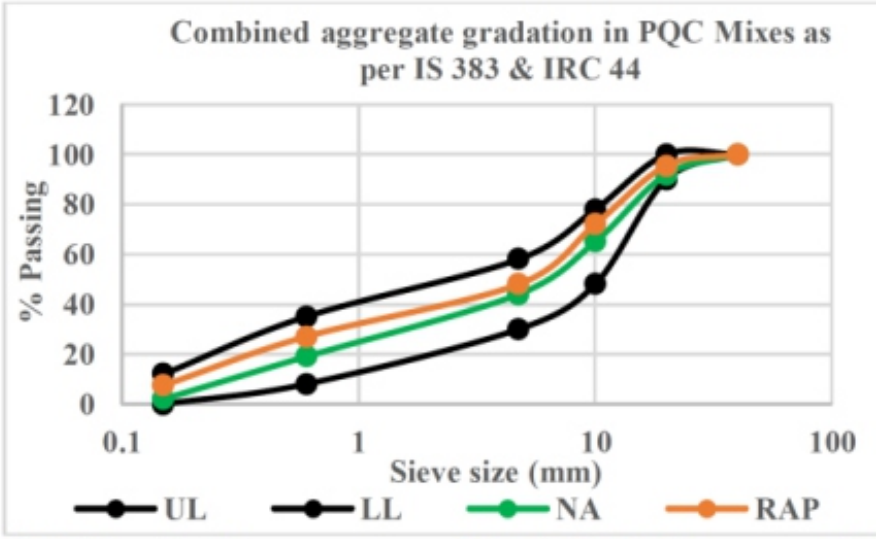


Fig.3. Combined aggregate gradation in PQC Mixes as per IS 383 & IRC 44.

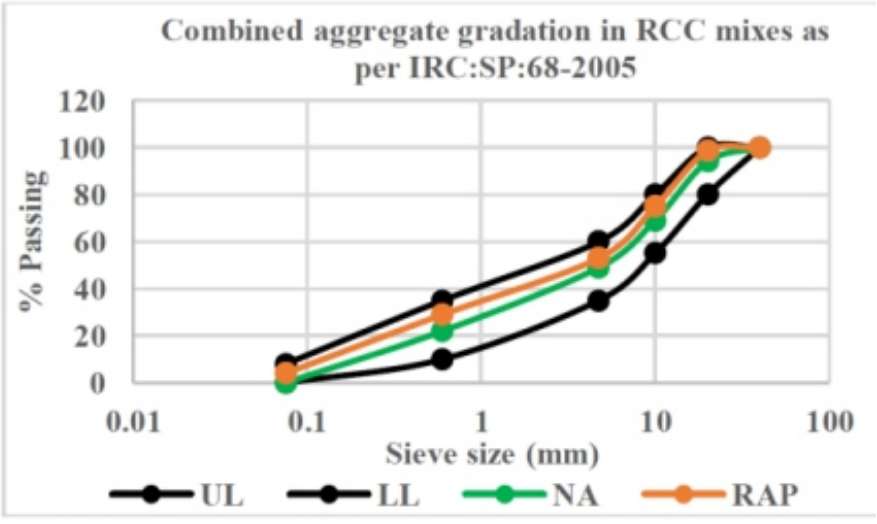


Fig.4. Combined aggregate gradation in RCC mixes as per IRC:SP:68-2005.

To study the effect of incorporation of RAP, in the subsequent mix, keeping similar w/cm, both natural coarse and fine aggregates were replaced by 50% CRAP and 50% FRAP by volume (CFR).

RCC in comparison with normal concrete pavement has different mix proportions. With cement and water content being on the lower side and fine aggregate on a higher side in an RCC, it delivers a stiff and dense concrete matrix with respect to a PQC, which is favorable for strength gain because of hydration of cement as well as friction amongst particles after being roller compacted. In order to achieve an optimum proportion for RCC mix, the mix proportions of normal PQC having 28 days compressive strength of 46 MPa is considered as a reference point. The sand to aggregate ratio and cement content in the PQC design mix was about0.45 and 13% by volume, respectively. The cement percentages were decreased from 13% to 9% by volume and Maximum Dry Density (MDD) and Optimum Moisture Content (OMC) for RCC mixes were obtained as per specifications of IS 2720(Part 7):1980 [23]. Each cement percentage was examined by simultaneously increasing the fine aggregate content such that the sand to aggregate (S/A) ratio increased from 0.45 to 0.50, and similarly from 0.5 to 0.55 by volume. The summarized results from the Proctor test (Fig.5.) for each mix concerning OMC MDD are shown in Table.3.

Fig.5. Concrete compaction carried out by Proctor Method for OMC-MDD purpose.

S. No.	Cement (%)	S/A ratio	MDD (kg/m^3)	OMC (%)
1	13	0.45	2287	7.25
2	13	0.50	2319	7.65
3	13	0.55	2371	7.80
4	12	0.45	2298	6.90
5	12	0.50	2356	7.47
6	12	0.55	2412	7.60
7	11	0.45	2315	6.40
8	11	0.50	2403	6.83
9	11	0.55	2454	7.17
10	10	0.45	2408	5.85
11	10	0.50	2443	6.10
12	10	0.55	2465	6.45
13	9	0.45	2304	5.15
14	9	0.50	2367	5.37
15	9	0.55	2418	5.75

Table.3. OMC-MDD values for the trial mixes for various cement and s/a ratio

The maximum dry density values increased in these mixes with a decrease in cement percentage from 13% to 10%. With a decrease in cement content, water demand also decreases. Statistically, the combined volume of cement and water that are replaced has to compensate with an equivalent volume-wise content of aggregate. Hence, for the same volume of the mix, the total aggregate content has to increase with the underlying condition that the ratio of fine aggregate to total aggregate should increase. By adopting the said procedure, a better packing of the matrix is observed indicated by an increase in maximum dry density. However, with the further reduction of cement to 9%, a decrease in maximum dry density value is observed. Now, this further reduction of cement content left a lesser amount of finer cement particles to fill the voids optimally, leading to unfilled voids that reduced the maximum dry density values as indicated by mixes with serial no. 13, 14 & 15 from Table.3. From all the mixes, two mixes having the highest MDD were chosen (S No. 11 & 12 from Table.3.). Further, the strength of these two mixes is compared at 7 days, with the former obtaining 27.2 MPa and the latter obtaining 31.4 MPa. Based on an MDD value of 2465 kg/m3 and compressive strength value of 31.4 MPa at 7 days, the RCC mix having 10% cement by volume and sand to an aggregate ratio of 0.55, was chosen as the control RCC mix ®*). This control RCC mix a cement content of 315 kg/m3 and a w/c ratio of 0.31, which is computed corresponding to the OMC value. Considering this R* mix as the control RCC mix, both coarse and fine natural aggregates were replaced by 50% coarse RAP and fine RAP aggregates respectively by volume in the subsequent mix (CFR*). Further, to study the effects of the incorporation of Silica fume in RAP incorporated RCC mix, silica fume replaced 15% of cement by volume in RAP RCC mix (SF-CFR*). The w/cm ratio for these mixes is 0.33 & 0.39, respectively, which are obtained from their corresponding OMC values from Moisture content-Dry Density graphs generated from Proctor Method as shown in Fig.6.

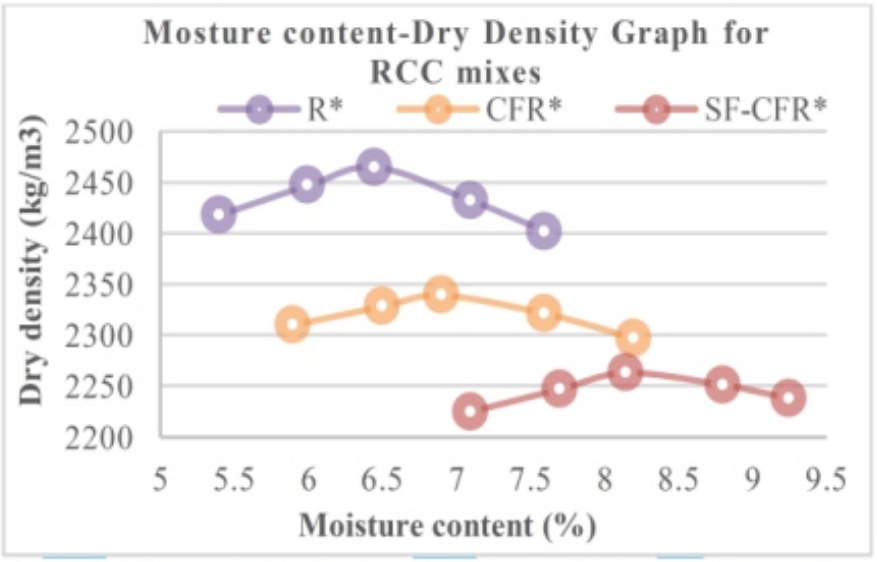


Fig.6. Moisture content – dry density graph and corresponding MDD-OMC plot for RCC mixes

The quantities of materials required for 1m3 of concrete mixes of PQC and RCC are presented in Table.4. and the preparation of RCC specimens is shown in Fig.7.

Material (kg/m³)	PQC	CFR	R*	CFR*	SF-CFR*
OPC	410	410	315	315	268
NCA	950	475	420	420	420
NFA	795	398	497	497	497
CRAP	-	452	-	400	400
FRAP	-	310	-	388	388
SF	-	-	-	-	33
W/CM	0.36	0.36	0.31	0.33	0.39

Table.4. Material quantities for 1 m3 of PQC and RCC mixes

Fig.7. Casting and Preparation of RCC cylindrical samples from RCC slab

2.3. Tests Conducted

Three cubes of size 100 mm of PQC mixes and three cylindrical core specimens of RCC mixes were tested for compressive strength on a Compressive Testing Machine (CTM) of capacity 2000 kN following IS 516 [24] on 7 and 28 days of curing age respectively. Two beam specimens of size 100 × 100 × 500 mm3 of PQC and RCC mixes were tested for flexural strength on a Flexure Testing Machine of 1000 kN capacity at 7 and 28 days of curing age respectively using a four-point bending test as per IS 516 specifications as shown in Fig.8.(a&b).

a) b)

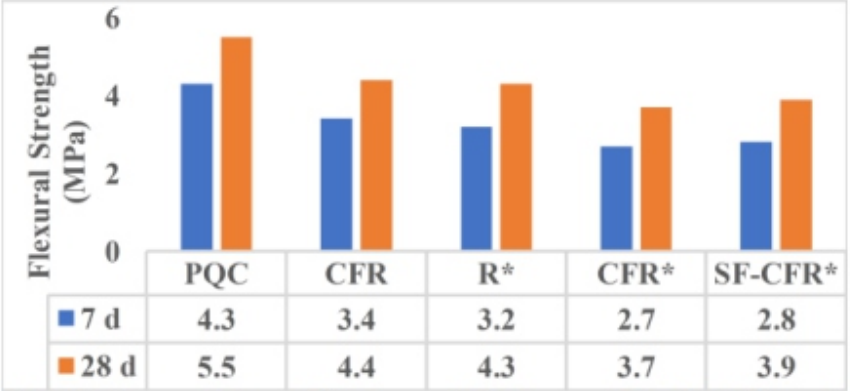
Fig.8. (a & b) Compressive and Flexural testing

III. RESULTS AND DISCUSSION

The results obtained from the compressive strength test and flexural strength test for all the mixes are represented in Fig.9. & Fig.10. respectively. The control mixes of PQC and RCC ®*) achieved their target compressive & flexural strength by a healthy margin reporting values as 46.5 MPa & 5.5 MPa and 39.3 MPa & 4.3 MPa respectively at 28 days of curing. While these values at 7 days of curing are 29.5 & 4.3 MPa and 31.4 & 3.2 MPa, respectively.

	PQC	CFR	R*	CFR*	SF-CFR*
7 d	29.5	21.5	31.4	23.8	24.5
28 d	46.5	35.5	39.3	30.1	32.8

Fig.9. Compressive Strength values of all mixes at 7 and 28 days of curing.



	PQC	CFR	R*	CFR*	SF-CFR*
7 d	4.3	3.4	3.2	2.7	2.8
28 d	5.5	4.4	4.3	3.7	3.9

Fig.10. Flexural Strength values of all mixes at 7 and 28 days of curing.

The reduction in flexural strength values for CFR and CFR* mix were about 21% & 20% and 16% & 14% w.r.t PQC and R* mix at 7 & 28 days of curing. This decrease in strength is due to the presence of asphalt layer and asphalt particles in coarse and fine RAP aggregates which tend to form a weaker ITZ and cement paste, thus deteriorating the bonding and increasing the chances of passing of crack through ITZ, rather than through aggregate [7], [8], [10] [15]–[19]. Further, the reduction in flexural strength on the addition of RAP aggregates in both PQC and RCC mixes is lower than that in compressive strength. This is attributed to the potential of the asphalt layer around RAP aggregates to act as a visco-elastic layer having a tendency to arrest cracks, making the cracks propagate around the aggregate taking a longer path and thus showing ductile failure in contrast to brittle failure in normal concrete in which crack propagates through the aggregate. The enhanced ductility can be beneficial for pavement applications making them perform better in fatigue as they can undergo larger deformations before failure [6], [8], [10], [16], [17].

Although the ITZ properties play an important role in influencing the strength properties, however, the comparatively lower strength reduction in RCC mixes with the addition of RAP against PQC mixes, shows that friction amongst particles in the RCC matrix have an added advantage in inhibiting the strength loss. Further, the addition of silica fume showed positive results with SF-CFR* mix showing an increase in compressive and flexural strength by about 3% & 6% and 4% & 5.4% w.r.t CFR* mix at 7 and 28 days respectively. This could be due to the better pore-refining property of Silica fume owing to its higher specific surface area and high silica content which could form extra CSH compounds densifying the ITZ and concrete matrix [18], [19].

On comparing the respective PQC and RCC mixes, although the 28 days compressive strength of mixes is higher than RCC mixes but the 7-day compressive strength of RCC mixes is higher than that of respective PQC mixes majorly due to friction amongst particles of RCC. The 7-day strength of PQC mixes is about 60-65% of 28-day compressive strength, while for RCC mixes this value of 7-day compressive strength w.r.t 28-day strength value is about 75-80%. This shows the early age strength achieved in RCC mixtures, majorly due to the friction amongst concrete matrix that creates an advantage for RCC pavements to be opened early for traffic. Both the PQC mixes comfortably achieved the 28 days compressive and flexural strength values of 35 Mpa and 4 MPa respectively. While for RCC mixes, all the three mixes could achieve the minimum compressive strength criteria of 27.6 MPa and minimum flexural strength criteria of 3.67 MPa for the RCC mixes to be used for the surface layer in pavements. This shows the feasibility of the use of RAP aggregates and SCMs as replacements of cement in PQC and RCC, which can also be sustainable approach with reduced usage of natural aggregates and cement, representing its eco-friendly prospect

IV. CONCLUSION

1. The mix design for the control PQC mix is based on specifications of IRC:44-2017, with cement content and sand/aggregate (s/a) ratio being 13% and 0.45 by volume, respectively, and w/cm being 0.36. For developing an RCC by altering the PQC mix design, an increased s/a ratio i.e. 0.55 is required at 10% cement content by volume of concrete mix, thus requiring a w/cm of 0.31.
2. RAP addition requires additional water in RCC mixes for compaction whereas in PQC the workability is not much affected. In PQC mixes the w/cm was kept constant at 0.36, whereas it was 0.33 and 0.39 for CFR* and SF-CFR* (RCC mixes), respectively.

3. The strength reductions in both PQC and RCC mixes, due to the addition of 50% fine and coarse RAP were in the range of about 15- 25%, which is much lesser than the reductions observed in the reviewed studies. This could be attributed to the standard combined aggregate gradations of RAP being incorporated in this study which adheres to the aggregate gradations specified by codal provisions. Hence, aggregate gradation has major influence on the strength/compaction efficiency of RCC mixes.
4. The addition of silica fume is found to be beneficial in improving the bonding of RAP aggregates with cement mortar, as both the compressive and flexural strength increased by about 6% at 28 days w.r.t RAP-RCC mix. RCC, thus obtained yields a compressive strength greater than 30 MPa comfortably and could be used for mid volume traffic roads such as State Highways.

REFERENCE

[1] Singh, S., Ransinchung, G. D., Debbarma, S., & Kumar, P, "Utilization of reclaimed asphalt pavement aggregates containing waste from Sugarcane Mill for production of concrete mixes", Journal of Cleaner Production,vol.174,pp.42-52,2018.
[2] Singh, S., Ransinchung, G. D., & Kumar, P, "Effect of mineral admixtures on fresh, mechanical and durability properties of RAP inclusive concrete", Construction and Building Materials,vol.156,pp.19-27,2017.
[3] Singh, S., Ransinchung, G. D., & Kumar, P., "Feasibility study of RAP aggregates in cement concrete pavements", Road Materials and Pavement Design,vol.20,no.1,pp.151-170,2019.
[4] Paluri, Y., Mogili, S., Mudavath, H., & Pancharathi, R. K, "A study on the influence of steel fibers on the performance of Fine Reclaimed Asphalt Pavement (FRAP) in pavement quality concrete", Materials Today: Proceedings,vol.32,pp.657-662,2020.
[5] Chyne, J. M., Sepuri, H. K., & Thejas, H. K, "A review on recycled asphalt pavement in cement concrete", Int. J. Latest Eng. Res. Appl,vol.4,no.2,pp.9-18,2019.
[6] Hossiney, N., Tia, M., & Bergin, M. J, "Concrete containing RAP for use in concrete pavement", International Journal of Pavement Research and Technology,vol.3,no.5,p. 251,2010.
[7] El Euch Ben Said, S., El Euch Khay, S., & Loulizi, A, "Experimental investigation of PCC incorporating RAP", International Journal of Concrete Structures and Materials,vol.12,no.1,pp.1-11,2018.
[8] Huang, B., Shu, X., & Li, G, "Laboratory investigation of portland cement concrete containing recycled asphalt pavements", Cement and Concrete Research, vol.35,no.10,pp.2008-2013,2015.
[9] Saluja, S., Kaur, K., Goyal, S., & Bhattacharjee, B, "Assessing the effect of GGBS content and aggregate characteristics on drying shrinkage of roller compacted concrete", Construction and Building Materials,vol.20,pp.72-80,2019
[10] Hassan, K.E., Brooks, J.J. and Erdman, M, "The use of reclaimed asphalt pavement (RAP) aggregates in concrete", Waste management series,vol.1,pp.121-128,2000.
[11] ACI Committee 325.10R-95, "Report on Roller Compacted Concrete Pavements",2001.
[12] Congress, I. R. "Guidelines for construction of roller compacted concrete pavements". IRC: SP, 68-2005.
[13] Settari, C., Debieb, F., Kadri, E. H., & Boukendakdji, O, " Assessing the effects of recycled asphalt pavement materials on the performance of roller compacted concrete", Construction and Building Materials,vol.101,pp.617-621,2015.
[14] Modarres, A., & Hosseini, Z, "Mech. properties of roller compacted concrete containing rice husk ash with original and recycled asphalt pavement material", Materials& Design,vol.64,pp.227-236,2014.

[15] Rezaei, M. R., Abdi Kordani, A., & Zarei, M, " Experimental investigation of the effect of Micro Silica on roller compacted concrete pavement made of recycled asphalt pavement materials", Intern. Journal of Pavement Engg.,vol.23,no.5,pp.1353-1367,2022.

[16] Debbarma, S., Ransinchung, G. D., & Singh, S, " Feasibility of roller compacted concrete pavement containing different fractions of reclaimed asphalt pavement", Construction and Building Materials,vol.199,pp.508-525,2019.

[17] Debbarma, S., Singh, S., & RN, G. R, "Laboratory investigation on the fresh, mechanical, and durability properties of roller compacted concrete pavement containing reclaimed asphalt pavement aggregates", Transportation Research Record,vol.2673,no.10,pp.652-662,2019.

[18] Debbarma, S., Ransinchung, G. D., Singh, S., & Sahdeo, S. K, "Utilization of industrial and agricultural wastes for productions of sustainable roller compacted concrete pavement mixes containing reclaimed asphalt pavement aggregates", Resources,Conservation and Recycling,vol.152,p.104504.2020.

[19] Debbarma, S., Ransinchung RN, G. D., & Singh, S, "Suitability of various supplementary cementitious admixtures for RAP inclusive RCCP mixes", International Journal of Pavement Engineering,vol.22,no.12,pp.1568-1581,2021.

[20] IRC: 44, 2017, "Tentative guidelines for cement concrete mix design for pavements. New Delhi, India: Indian Roads Congress"

[21] IS 383: 2016, "Coarse and Fine Aggregates for ConcreteSpecification".

[22] IS 8112 : 2013, "Ordinary Portland Cement, 43 Grade –Specification".

[23] BIS (Bureau of Indian Standards), 1980. IS 2720-7: "Methods of test for soils, Part 7: Determ. of water contentdry density relation using light compaction".

[24] IS 516: 2014. "Method of tests for strength of concrete". IS: 516-1959 (Reaffirmed 2004).

ISSN: 2394-2827

THE WATER QUALITY EXITING THE ARAD SEWAGE TREATMENT PLANT

1BACALU-RUS SNEJANA DENISA, 2BOTH IOAN
Arad Technical High School for Constructions and Environmental Protection, Arad, Romania
1Aurel Vlaicu University of Arad, Arad, Romania
2Politehnica University of Timisoara, Timisoara, Romania,

A B S T R A C T

The discharge of insufficiently purified effluents led to the alteration of the quality of water courses and the appearance of a wide range of pollutants: organic and microbiological substances. The degree of water pollution, discharged directly into the effluent can lead to an imbalance of the ecosystems and its monitoring is necessary to avoid destruction in the food chain. In the assessment of water pollution, sudden increases in the values of organic matter are particularly significant, which raises the intervention of a pollution. The organic substances in water are determined by the oxidation of organic matter with oxidants such as potassium permanganate and potassium bichromate by measuring BOD5 and COD, respectively. The paper presents the efficiency of the biological treatment process of a sewage treatment plant by monitoring of waste water through the BOD5 and COD values. The exit values are bellow the allowable limits given in NTPA 001/2002and NTPA 002/2002.

Keywords - *Sewage Treatment Plant, BOD5, COD, Potassium Permanganate and Potassium Bichromate*

I. INTRODUCTION

The discharge of insufficiently purified effluents led to the alteration of the quality of water courses and the appearance of a wide range of pollutants: organic substances that are difficult to degrade, compounds of nitrogen, phosphorus, sulfur, trace elements (copper, zinc, lead), pesticides, organochlorine insecticides, detergents, etc. Also, in many cases, high levels ofimpurities of bacteriological nature are noted.

Water quality can lead to an imbalance of ecosystems and its monitoring is necessary to avoid destruction in the food chain. A study on changes in water quality in urban areas was carried out by Berbecea et al. [1] who highlighted a major pollution around urban settlements by monitoring several points on the Mures River.

Due to the current climate changes and the increase in the anthropogenic level, it is difficult to maintain water quality at certain standards. Monitoring the impact of human activity on water resources was studied by Smuleac et al. [2]. The impact of human activity on the Mures River was reduced, below the allowable limits, following the monitoring of some water quality indicators.

Another monitoring of the impact of different anthropogenic activities was highlighted by HAMEED et al [3], studying parameters such as EC and BOD, in a lake in Iraq. It is suggested that monitoring of the lake is necessary for proper management.

When we think about protecting the environment, we think about protecting nature. A recent study was done by Pascalau et al., [4], who studied the origin of the term nature from several countries, reaching the conclusion that scientists should propose environmental conservation policies depending on the natural substrate of each country [4].A few years ago Dimitrovska et al. [5], studied several parameters of the waters of the great rivers, in the Republic of Macedonia, such as: nitrates, nitrites and BOD5, since a rather serious pollution of the rivers in the urban environment was reported due to the increase in the flow of waste water which are often discharged into untreated surface waters. As a result of the research, a water pollution above the allowed limit was found, in some periods of the year, which highlights the fact of inefficient purification of the used water before sending it to the emissary [5].Nitrate concentrations often increase in a gradual manner depending on the flow of rivers through the permeable layers of hydrographic basins. Neal et al. [6], in their work, which monitored two tributaries of the Thames, observed a minor decrease in nitrates during the spring and summer both to the low flow and due to the rather high biological activity [6].

A quick determination of the water quality index can be done knowing the dissolved oxygen index. These are some of the simple indicators that determine the pollution of the hydrographic basins, which were studied by Sanchez-Choliz et al. [7], for two years on the waters of two rivers and ponds in the Paris Park area, finding variations in the quality of the water due to the influence of climatic conditions. [7].

This article presents the monitoring of domestic and industrial water before and after purification following its safe discharge to reduce and prevent water pollution and thus achieve a good ecological condition and maintain the aquatic balance in the Mures river. BOD5 and COD recordings are presented in two months from different seasons when the water flow has different variations at the entrance of the treatment plant.

II. METHODS AND MATERIALS

The city of Arad has a high-performance mechano biological purification station intended for the purification of domestic and industrial water, the water being discharged into the Mures river and not being used for consumption. Mechanical purification is carried out in the inlet structure, rainwater pumping station and rainwater basin, grates, skimmers and grease separators, distribution chamber 1, and biological purification is carried out in anaerobic basins, anoxic tanks, aeration basins, distribution chamber 2, and final sedimentation basins. The resulting residues are treated through the sludge pumping station, the sludge mechanical thickening area, the sludge dehydrationarea and the transport system.

The water samples were collected in glass or polyethylene bottles, according to the prescriptions that refer to the sampling of surface and used water, and before taking the water samples, the laboratory vessels were cleaned with washing solution, rinsed abundantly with (bi)distilled water and then with thesample to be analyzed.

Water samples were analyzed immediately after collection, and those that required preservation until analysis, were preserved at a temperature between 20℃ and 50℃. Acidification with sulfuric acid at pH < 2 was also performed to facilitate preservation.The samples were handled and transported from the sampling site to the laboratory in polyethylene containers.

After collecting, samples were transported to the laboratory as quickly as possible.

The samples were stored depending on the moment of arrival in the laboratory on the work table (for samples analyzed from the station), or in the fridge.Biological oxygen demand (BOD5)The principle of the method consists in determining the oxygen consumed in five days by microorganismsin the water, by the difference between the amount of oxygen in the water sample on the day of collection and after 5 days from collection.

The following materials are required to perform the measurements:

- water sample from the time of collection;
- water sample kept in the dark for 5 days;
- alkaline mixture;
- starch, 1% solution;
- 0.025 N Na2S2O3solution;
- manganese sulfate (MnSO4·6H2O) 50%, or manganese chloride 40%;
- diluted sulfuric acid 1:3;
- burette.
- Erlenmeyer flask;

According to the ISO 5813 standard [8], the procedure is the following:

be analyzed was collected in two bottles of known volume. The oxygen was fixed in one of the bottles, and the second bottle was kept in the dark, at a temperature of 20℃, for 5 days. In the bottle in which the oxygen was fixed, 2 ml of the manganese chloride solution wasadded and 2 ml of the alkaline iodide azide mixture. The cap was fixed andthe contents of the bottle were shaken. In the presence of oxygen, a reddish-brown precipitate is formed, and in its absence, the precipitate remains white. After the complete deposition of the precipitate, 10 ml of the liquid was removed and 5 ml of H2SO4 (1:3) was added. The sample was mixed until the precipitate dissolved. The quantitative content was transferred into an Erlenmeyer flask and titrated with sodium thiosulphate until the yellow color appeared, then 1 ml of starch was added and the titration was continued until the blue color of the starch completely fades. After 5 days, BOD5was determined according to the formula:

$$\text{mg BOD5/dm3} = A - B \quad \text{.....(1)}$$

- A: the amount in mg oxygen/dm3existing in the water sample at the time of collection
- B: the amount of oxygen in mg/dm3found in water sample after 5 days.

Determination on the diluted water sample was performed according to the following. Into a 1000 ml volumetric flask, the dilution water was added ¾ of the flask, then a certain amount of water to be analyzed was added and fill it up to the mark with the dilution water. It was homogenized and with the help of a siphon, two Winkler bottles of known volume were filled. In one of the bottles, the dissolved oxygen was determined immediately, and the second bottle was incubated for 5 days, in the dark and at 20℃, after which the dissolved oxygen was determined according to the formula

$$\text{mg BOD5/dm3} = [(A-B)-(a-b)]*D \quad \text{.....(2)}$$

- A: the amount of dissolved oxygen in mg oxygen/dm3determined in the diluted water to be analyzed immediately after the dilution,
- B: the amount of dissolved oxygen in mg oxygen/dm3determined in the diluted water to be analyzed, after 5 days,
- a: the amount of dissolved oxygen in mg oxygen/dm3of the dilution water, determined immediately after the dilution,
- b: the amount of dissolved oxygen in mg oxygen/dm3 of the dilution water, after 5 days,
- D: the dilution factor.

Chemical oxygen demand COD- Potassium Dichromate Method

In the assessment of water pollution, sudden increases in the values of organic matter are particularly significant, which raises the level of the pollution.

The organic substances in water are determined by the oxidation of organic matter with oxidants such as K2CrO7. It represents the mass concentration of oxygen equivalent to the amount of potassium bichromate consumed for the oxidation of dissolved and suspended organic matter present in water in an acid environment.

According to NTPA 002, the maximum allowable limit of COD is 500 mg/l.

The following materials wereused to perform the measurements:

- thermoreactor ECO 6 VELP for heating samples to 150℃,
- heat-resistant reaction tubes 200 ml,
- air coolers,
- anti-splash bells,
- Teflon sleeves,
- graded cilinders
- SOLARUS automatic burette
- graded pipettes
- automatic pipette
- Erlenmeyer flasks
- pike
- HIRSCHMAN dispenser
- magnetic stirrer

According to the quality standard ISO 6060 [9], the organic and anorganic (oxidizable) substances that were present in the water were oxidized with an excess potassium dichromate solution, in a highlyacidicenvironment, in the presence of silver sulfate as catalyst. Excess potassium dichromate was then titrated with iron (II) sulfate and Mohr's salt, using ferrous phenanthroline (ferroin) as an indicator.A quantity of 10 cm3of water sample was introduced into the heat-resistant glass tube.

The sample to be analyzed (10 ml) was transferred into the reaction tubes, adding 5 ml of mercury sulfate solution in potassium dichromate and sulfuric acid, stirring carefully. Then 15 ml of silver sulfatewas added in sulfuric acid and the vessel with sulfatewas added in sulfuric acid and the vessel with the

refrigerant was assembled. The reaction mixture was brought to boiling point in ten minutes and boiling was continued for another 10 minutes. The temperature of the reaction mixture was 1500C.

The vessel was cooled in cold water, at a temperature of approximately 600C, and the refrigerant was rinsed with water. The refrigerant was removed, the reaction mixture was diluted with approximately 75 ml of bidistilled water, then cooled to room temperature. The excess of potassium bichromate was titrated with iron (III) and ammonium sulphate, in the presence of an indicator (ferroin); one or two drops of indicator were added.

The turning point of the indicator was noted when the sudden colour change from blue green to brownoccurred, even if the blue-green colour reappeared after a few minutes.

The control sample was prepared according to the principle above, replacing the sample with the same amount of bidistilled water.The dissolved oxygen was calculated with the relation:

$$8000 * c * (V1-V2) /V0 \ldots\ldots\ldots\ldots\ldots\ldots (3)$$

where:

- c: the concentration of the calculated iron and ammonium solution, in moles/l
- V0: the volume of the sample for analysis, undiluted, in ml
- V1: the volume of the solution of iron and ammonium sulphate, used for the titration of the control sample, in ml
- V2: the volume of the solution of iron sulphate and Mohr's salt, used for titration of the sample, expressed in ml.
- 8000: is the molar mass of O2, in mg/l

III. RESULTS AND DISCUSSIONS

BOD5 is the primary design parameter for the biological system. If BOD5 concentrations of the influent are stable, a decrease in flow will reduce influent organic loading and increase tank retention time, which may improve BOD5 removal efficiency (if other operating conditions are favourable). However, activated sludge systems can adapt more effectively to a high organic loading if the hydraulics of the system are stable. In general, user flow adjustments should not be used to measure organic loading to the detriment of overall system balance. Other process adjustments such as reduced sludge losses should be applied to accommodate the increased organic loading as long as the effluent quality is acceptable. Figures 1,2 show the BOD5values determined within this project at the Arad Sewage Treatment Plant, every day from June and October 2021. The value allowed by NTPA 002/2002, for the BOD5 content in the wastewaterentering the station is 300 mg/l. The allowed value according to NTPA 001/2002, for the content of BOD5 in the wastewater at the exit from the station is 25 mg/l.According to Figures 1,2, a higher value of the amount of BOD5 present in the wastewater is observed at the station entrance in June, and a higher value at the station exit in October.According to Figures 3,4. a substantial decrease in the value of COD from the wastewater entering the station is observed compared to that existing in the water leaving the station, which means that this process is effective. The allowed value by NTPA 002/2002, for the content of COD in the wastewater entering the station is 500 mg/l while the allowed

value according to NTPA 001/2002, for the content of COD at the exit of the station is 125 mg/l.

Figure 1 Comparative BOD_5 values from the entry-exit of the station-month of June 2021

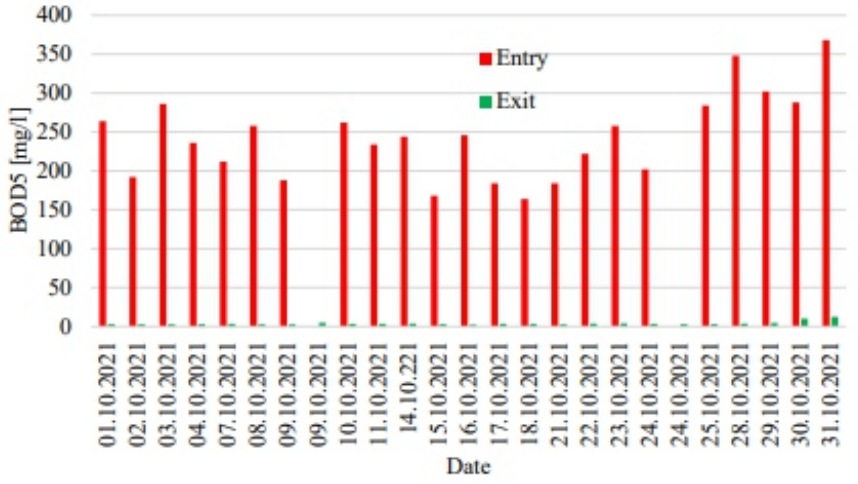


Figure 2 Comparative BOD_5 values from the entry-exit of the station-month of October 2021

Figure 3 Comparative COD values from the entry-exit of the station-month of June 2021

Figure 4 Comparative COD values from the entry-exit of the station-month of October 2021

IV. CONCLUSION

For domestic and industrial wastewater to be discharged into the Mures River under the conditions stipulated by law, it must be purified by mechanobiological processes presented in this paper. The results of the water analyses were interpreted and compared with the main indicator parameters of the Normative on the conditions of wastewater discharge in the sewage networks of the localities and directly in the treatment plants, NTPA 001/2002 and NTPA 002/2002. The purpose of this regulation is to establish the conditions under which the discharge of wastewater into the receivers is accepted, so as to ensure their protection and normal functioning, as well as to protect the environment from the adverse effects of wastewater discharges.The study of water quality indicators wasperformedthroughout the year 2021 and compared forJune and October 2021 both at the entry of the wastewater ofthe station and at the exit of the treated water from the station. The purpose of the work was fulfilled, showing that, according to the results obtained following the analysis of the indicators monitoredwithin the project, the water passing through the mechano-biological treatment process from the Treatment Plant in the Municipality of Arad, has a good quality, according to the allowed values in the standards and can be safely discharged into the effluent.

REFERENCE

[1] Berbecea Adina, Radulov Isidora, Niţa L, Vogyvolgyi C, Laţo Alina, Őkros A, Crista F, Laţo Ki,2014, The Quality OfMaros River Water In Romania Hungary Cross Border Area. Research Journal of Agricultural Science . 2014, Vol. 46 Issue 2, p3-13. 11p

[2] Şmuleac Laura, Lavinia Ştefanca, AnişoaraIenciu, R Bertici, A Şmuleac(2017). Influence of anthropogenic activities on Mures River water quality, Research Journal of Agricultural Science, Vol. 49 (3)

[3] Hameed, A., Alobaidy, M. J., Abid, H. S., &Mauloom, B. K. (2010) Application of water quality index for assessment of Dokan lake ecosystem, Kurdistan region, Iraq. Journal of Water Resource and Protection, 2, 792–798

[4] Pașcalău R, S Stanciu, Laura Șmuleac, A Șmuleac, C Sălășan, Alina-AndreeaUrlică (2021). Protecting nature through languages, Research Journal of Agricultural Science, Vol. 53 (2)

[5] DimitrovskaOlgica, Markoski B., ApostolovskaToshevskaBilijana,Milivski I., Gorin S., Surface water pollution of major rivers in the Republic of Macedonia, Landscape, Environment, European Identity, 4-6 November, 2011, Bucharest.

[6] Neal C., JarvieP.Hellen, Neal Margaret, Hill Linda, Wickham Heather, Nitrate Concentrations In River Waters Of The Upper Thames And Its Tributaries, Science Of The Total Environment 365(2006), 15-32.

[7] Sanchez E., Colmenarejio F.M, Vicente J., Rubio A., Garcia G.Maria.,Travieso Lisette, Borja R., Use of the water quality index and dissolved oxygen deficit as simple indicators of watersheds pollution, Ecological indicators 7 (2007) 315-328

[8] ISO 5813:1983 Water quality — Determination of dissolved oxygen — Iodometric method [9] ISO 6060:1989 Water quality — Determination of the chemical oxygen demand

ISSN: 2394-2827

OIL PALM BOTTOM ASH AS PARTIAL REPLACEMENT FOR FINE AGGREGATE IN SAND-CEMENT BRICKS

1SALMALIZA SALLEH, 2TEE MING WI, 3MOHD RASHID YA'ACOB

1Faculty of Engineering and Science, University of Greenwich, United Kingdom
2,3Centre for Infrastructure Geo-Hazards and Sustainable Materials, SEGI University, Malaysia

ABSTRACT

As oil palm is one the most essential product of Malaysia, it generated high amounts of waste. This paper presents a research investigation of the Oil Palm Ash (OPA) utilisation to partially replace sand in sand-cement bricks. The objectives are to obtain the optimal design mix of oil palm bottom ash as a partial replacement for the fine aggregate in sandcement bricks based on its workability during the fresh stage and to analyse the density and compressive strength of sand cement bricks that contain different percentages of OPA. Laboratory tests were carried out with OPA partial replacement percentages of 0% (control), 10%, 30% and 50%. Compressive strength tests were done on Day 1, Day 7 and Day 28 of the full water curing regime. The resultshows that the higher the percentages of OPA replaced sand in cement brick mixture, the higher the water-to-cement ratio is required to fulfil the targeted fresh concrete workability.It was also proven that OPA as the replacementin sand-cement brick will reduce the density and compressive strength of the brick. The highest strength developed by the OPA brick is on Day 28 and with 10% of the OPA replacement level which was achieved at 8.50MPa.

Keywords *- Oil Palm Ash, Workability, Replacement, Compressive Strength, Brick*

I. INTRODUCTION

Malaysia Palm Oil Council [1] reported that Malaysia was having 25.8% and 34.3% of the world's palm production and exports in the year2020.However, the increase in palm oil production leads to thegeneration of a large amount of waste materials and one of the most common wastes is oil palm ash, OPA.OPA is a by-product from palm oil mills by burning the remaining extracted palm oil shells, fruit branchesand palm oil fibres. The colour of the OPA may varyfrom whitish grey to shade depending on the operating system used by the palm oil industry. Ooi et al [2] reported that 4 million tonnes of OPA were generated annually in Malaysia, of which 5% of the mass is known as oil palm bottom ash [3].These ashes cannot be used as a fertilizer in agriculture because of their insufficient nutrients [4]. As a result, OPA becomes an unprofitable waste material and potential to cause serious environmental pollution. On the other hand, the demands for construction raw materials such as cement, sand and gravel have increased significantly due to the rapid growth of the construction industry. Most of the materials used are obtained from natural resources which are nonrenewable.

Therefore, in this research, the OPA was proposed to partially replace the sand in the sand-cement brick making. Then, the brick specimens were examined in terms of workability, density and compressive strength in order to determine their feasibility in construction industries.

II. METHODOLOGY

The experimental work was conducted at the SEGI University's concrete laboratory concrete. The overall work comprises three stages: material preparation, the casting of specimens and testing.

I. Materials

The Ordinary Portland Cement (OPC) in accordance with the ASTM C150 Standard [5]of strength class 42.5was used throughout the experimental work. Mine sand ranging between 75 μm to 4.75mm wasused as fine aggregates. The tap water supplied at the laboratory was used for the concrete mixing and curing process. The oil palm ash was collected from apalm oil mill located in the state of Johor, Malaysiaas shown in Figure 1.

Figure 1: Oil Palm Ash (OPA)

ii. Casting of specimen

The sand-cement bricks were mixed by using different oil palm ash (OPA) percentages of mine sand replacement which consists of 0% as a control, 10%, 30% and 50%. The mix design was calculated by using the volumetric ratio method [6] by using a1:4 cement-to-sand ratio.Once the mixing process hascompleted, the mixturewas then placed into themould with the size of 65 mm x 100 mm x 210mm. This dimensionisaccording to BS 4729 [7] standard forbrick. The next day, it was demoulded and went for water curing until the testing day on day 1,day 7andday 28.

iii. Testing

The workability of the fresh mixtures wascarried out by using the Slump Test method in accordance withtheASTM C143 Standard[8].Next, the density test of hardened samples was done in accordance with EN 12390-7 Standard [9].Finally, the compressive strength test of hardened samples was

conductedaccording to theASTM C109-07 Standard[10].The flowchart of this research methodology is shownin Figure 2 below.

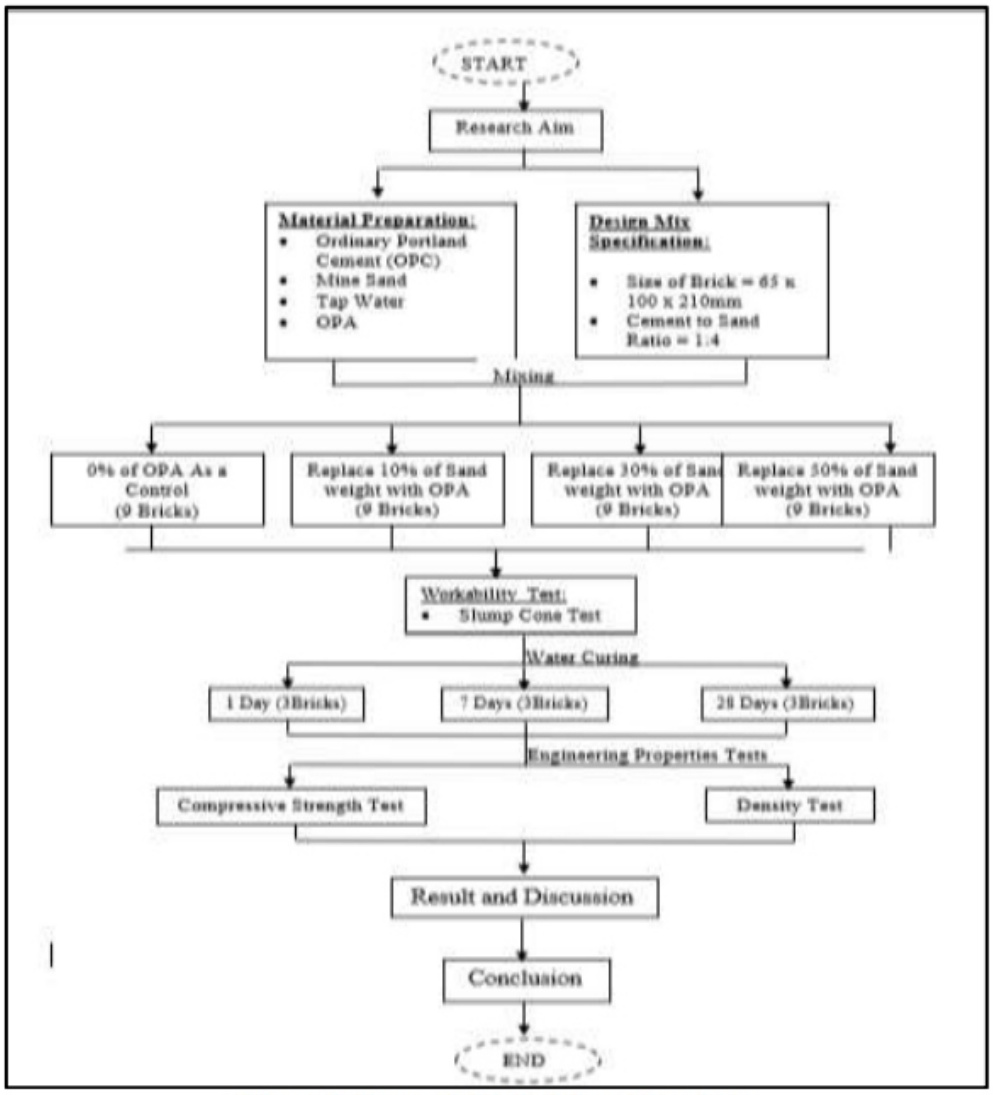


Figure 2: Research Methodology Flowchart

III. RESULTS AND ANALYSIS

The OPA used for this research was black in colour and observably powder form in nature. the sieve analysis test, the total amount of OPA passing through the 45 μm sieve was 85%.The specific gravity of the OPAwasfound to be 1.35, almost two times lower than the specific gravity of minesand. According to other research findings [11], [12], [13],and [14], thespecific gravity of OPA was in the range of 1.80 to 2.20. The difference in the specific gravity value may be due to different sources of OPA.

I. Workability

From the result summarised in Table 1 and Table 2, it is clearlyshown that the higher the percentages of OPA replaced sand in the sand-cement brick mixture,the higher the water-to-cement ratio is required to fulfil the targeted workability.

OPA Partial Replacement	Slump Test Value (mm)
0% of OPA and 100% of Sand	36
10% of OPA and 90% of Sand	30
30% of OPA and 70% of Sand	25
50% of OPA and 50% of Sand	18

Table 1 Slump Test Result for 0.9 Water-to-Cement Ratio

OPA Partial Replacement	Slump Test Value (mm)
0% of OPA and 100% of Sand	55
10% of OPA and 90% of Sand	46
30% of OPA and 70% of Sand	35
50% of OPA and 50% of Sand	30

Table 2 Slump Test Result for 1.2 Water-to-Cement Ratio

The targeted range of workability based on slump test value is between 20-80mm which is the requirement stated under theBS EN 206-1:2021 Standard [15]. After the slump test was conducted, it shows that the desired water-to-cement ratio for the mixture with 0% of OPA and the mixture with 10% of OPA were 0.90 while the desired water-to-cement ratio for a mixture with 30% of OPA and a mixture with 50% of OPA were 1.20 in order to reach the targeted range of slump. The final slump value used in this research was controlled in between the range of 30-36mm.

ii. Density

Table 3below shows the result obtained from the density tests for Day 1, Day 7 and Day 28.

Day	0%	10%	30%	50%
1	1882.78	1868.13	1655.68	1553.11
7	1949.39	1882.78	1575.09	1472.53
28	1860.81	1860.81	1597.07	1406.59

Table 3 Average Density (kg/m^3) of Hardened OPA-Sand-Cement Brick on Day 1, Day 7 and Day 28

The density of the OPA-sand-cement brick was lower when the replacement percentages of OPA increased.This result corresponds with the specific gravity of OPA which is lower than the mine sand. The illustration can clearly be seen in Figure 3 below.

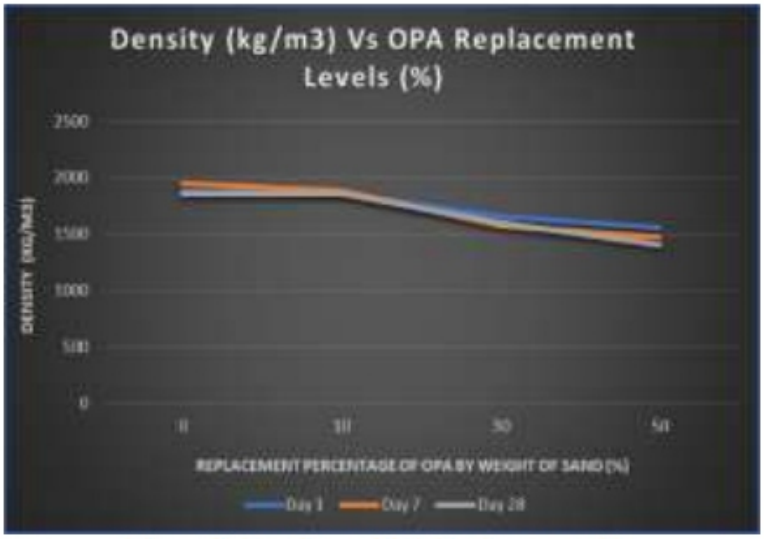


Figure 3: Density vs OPA Replacement %

These findings are comparable with other research done by NurainIzzati [16], Haspiadi and Kurniawaty[17] and Kamarulzaman [18] where they found that the replacement of OPA in cement brick will reduce the density of bricks.

According to the ASTM C90 Standard [19], the density of lightweight brick should be less than 1680 kg/m3while the density of medium-weight brick should be between the range from 1680 kg/m3to 1750 kg/m3. Moreover, bricks with a density of more than 1750 kg/m3should be classified as heavy-weight bricks. Hence, it can be concluded that bricks with 0% and 10% OPA replacement can be classified as heavyweight bricks. The bricks with 30% and 50% OPA replacement should be classified as lightweight bricks

iii. Compressive strength

Table 4below shows the compressive strength result of OPA-sand-cement bricks obtained from experiments for Day 1, Day 7 and Day 28 with different OPA replacement levels.

Day	0%	10%	30%	50%
1	8.93	4.47	1.86	1.26
7	11.16	5.46	3.39	2.62
28	14.59	8.50	3.72	2.83

Table 4 Average Compressive Strength(N/mm^2) for Day 1, Day 7 and Day 28

According toASTM C129 and ASTM C90 Standards, bricks with a compressive strength greater than 11.70 MPa are known asload-bearingbricks while lowerthan thatbut greater than 3.45 MPa are known asnon load-bearing bricks [19].Therefore, the control brick on Day 28 recorded the highest strength among all the bricks tested and it can be classified as loadbearing brick as its compression strength was greater than 11.70MPa.On the other hand, all the bricks with partially replaced sand with OPA are considered as non-bearing bricks. The highest strength developed by the OPA brick is on Day 28 and with 10% of theOPA replacement level which has achieved 8.50MPa.The results are illustrated in Figure 4 below.

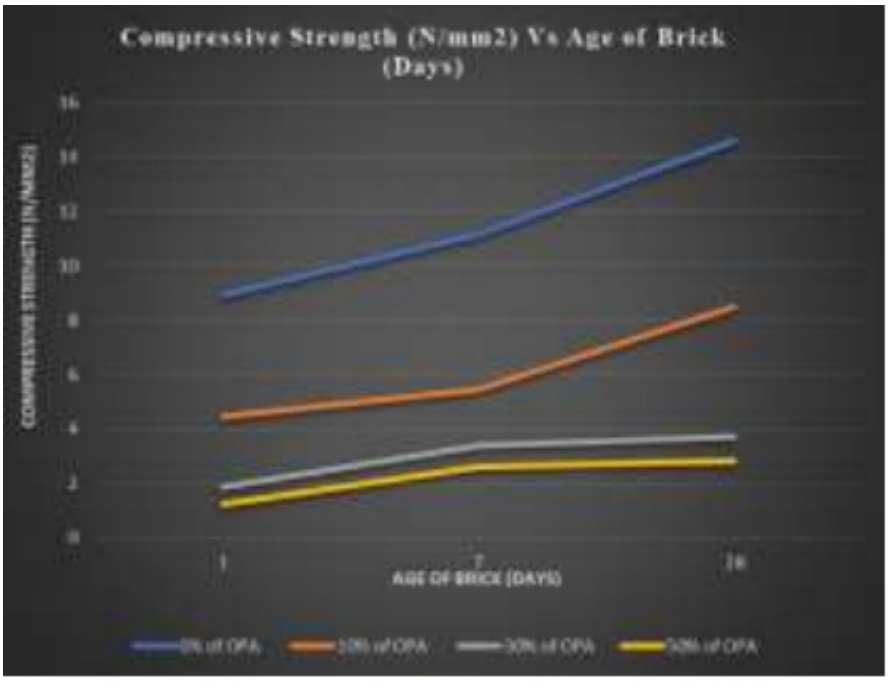


Figure 4: Compressive Strength vs Age of Bricks

The low density of OPA will increase the totalvoids in the mixture and result in weak bonding between the particles, causing the reduction of the bricks' compressive strength.In summary, it was proved that the replacement of OPA in sand-cement brick will reduce the compressive strength of the brick and the results obtainedtally with the previous research byKhairunisa [20], Zarina [21], Haspiadi and Kurniawaty [17] and Kamarulzaman[18].

IV. CONCLUSION

The sand-cement bricks with partially replaced sand by oil palm ash generally have lower workability, density, and compressive strength. It can be concluded that OPA as a partial replacement for sand in sand-cement brick was not feasible for loadbearing bricks. However, as it is suitable as non-load bearing brick, it can be considered as anenvironmentally friendly brick containing lessnaturalsand and it is possible to be produced for use in the construction industry. Success in integrating this palm oil industry waste generally helps the industry to be more environmentally friendly as the pollution issue related to the disposal of oil palm ash at dumping sites can be reduced.

ACKNOWLEDGEMENT

The authors would like to thank MTC Engineering Consultancy Sdn. Bhd. for providing the oil palm ash, SEGi University for allowing the usage of the concrete laboratory and the University of Greenwich for supporting this research work.

REFERENCE

[1] Malaysian Palm Oil Council. "Malaysian Palm Oil Industry". (n.d.). Retrieved February 26, 2022, from https://mpoc.org.my/malaysian-palm-oil-industry/
[2] Z.X. Ooi, H. Ismail, A.A. Bakar, Y.B Teoh "A review on recycling ash derived from Elaeisguineensis by-product" Bioresources, 2014, vo.9 no. 4, p.p 7926-7940.
[3] Mohammad Momeen, U. I,"Feasibility Study of Ground Palm Oil Fuel Ash As Partial Cement Replacement Material In Oil Palm Shell Lightweight Concrete", Masters Thesis, 2015.
[4] Tay, J.-H., & Show, K.-Y. "Use of ash derived from oil-palm waste incineration as a cement replacement material". Resources, Conservation and Recycling, 13(1), 27-36, 1995.
[5] ASTM Standard Test Method C150-07, "Standard Specification for Portland Cement", 2012.
[6] Ismail, Isham&Shahidan, Shahiron, "A Preliminary Modified Volumetric Mix Design for Self-Compacting Concrete (SCC) by Utilizing Asphalt Dust Waste (ADW)", International Symposium on Civil and Environmental Engineering 2016 (ISCEE 2016)Volume: 103, 2016.
[7] BS 4729:2005+A1:2016, "Clay bricks of special shapes and sizes. Recommendations", 2016.
[8] ASTM Standard Test Method C143 "Slump of Hydraulic Cement Concrete", 2003.
[9] EN 12390-7:2019, "Testing hardened concrete - Part 7: Density of hardened concrete", 2019.
[10] ASTM C109, "Standard Test Method for Compressive Strength of Hydraulic Cement Mortars", 2010.
[11] Kanadasan, J.; Razak, H.A. "Engineering and sustainability performance of self-compacting palm oil mill incinerated waste concrete". J. Clean. Prod.,89, p.p.78–86, 2015.
[12] Abdullahi, M.; Al-Mattarneh, H.; Hassan, A.A.; Hassan, M.H.; Mohammed, B. "Trial mix design methodology for Palm Oil Clinker (POC) concrete". In Proceedings of theInternational Conference on Construction and Building Technology, Kuala Lumpur, Malaysia, 16–23 June 2008.
[13] Ahmad, M.H.; Noor, N.M. "Physical properties of local palm oil clinker and fly ash". In Proceedings of the 1st Engineering Conference, Kuching, Malaysia, p. 162, 27–28December 2007.
[14] Mohammed, B.S.; Al-Ganad, M.A.; Abdullahi, M. "Analytical and experimental studiesoncomposite slabsutilising palm oil clinker concrete". Constr. Build. Mater., 25, p.p. 3550–3560, 2011.
[15] BS EN 206:2013+A2:2021. "Concrete. Specification, performance, production and conformity", 2021.
[16] NurainIzzati, M. Y., Suraya Hani, A., Shahiron, S., Sallehuddin Shah, A., Mohamad Hairi, O., Zalipah, J., Noor Azlina, A. H., Mohamad NorAkasyah, W. A., & Nurul Amirah, K. "Strength and water absorption properties of lightweight concrete brick". IOP Conference Series: Materials Science and Engineering, 513, 012005. https://doi.org/10.1088/1757-899x/513/1/012005, 2019.
[17] Haspiadi, H., &Kurniawaty, K. "PemanfaatanLimbahPadat Abu Cangkang dan SeratKelapaSawitdari Boiler untukPembuatan Bata BetonRingan". JurnalRisetTeknologiIndustri, 9(2), 120–128. https://doi.org/10.26578/jrti.v9i2.1710, 2016.
[18] Kamarulzaman, N. A., Adnan, S. H., Mohd Sari, K. A., Osman, M. H., Ahmad Jeni, M. L., Abdullah, M. S., Ang, P. S. E., Yahya, N. F., Yassin, N. I. M., &WaheeAnuar, M. N. A. "Properties of Cement Brick

Containing Expanded Polystyrene Beads (EPS) And Palm Oil Fuel Ash (POFA)". Journal of Science and Technology, 10(4). https://doi.org/10.30880/jst.2018.10.04.008, 2018.

[19] ASTM C90-22. "Standard Specification for Loadbearing Concrete Masonry Units", 2022.

[20] Khairunisa, Muthusamy & Ibrahim, Muhammad & Othman, Nor &Budiea, Ahmed & Wan Ahmad, Saffuan."Properties of sand cement brick containing groundpalm oil fuel ash as fine aggregate replacement." Challenge Journal of ConcreteResearch Letters. 9. 71. 10.20528/cjcrl.2018.03.001., 2018.

[21] Zarina, Caleb & Sie Yon, John Lau &Tuah, Acquah & Ngee, Ngu& Danquah, Michael. "Synthesis and performance analysis of oil palm ash (OPA) based adsorbent as a palm oil bleaching material". Journal of Cleaner Production. 139. 10.1016/j.jclepro.2016.09.004, 2016.

ISSN: 2394-2827

AN APPROACH OF LEARNING ACTIVITIES TOWARDS ARCHITECTURAL HERITAGE AWARENESS IN SSRU ARCHITECTURE STUDENTS

PIPAT SAKSIRIKASEMKUL, 2 SURIYAN CHANSAWANG

1,2College of Architecture SuanSunandha Rajabhat University

A B S T R A C T

This study aims to investigate the learning outcome of architecture students towards heritage study. The students take part in several courses in a 5-year program. Learning activities apply to each course in order to raise heritage value awareness. By doing this, the study is conducted to understand the reflection of students on activities. Quantitative and qualitative methods are integrated into analysis and discussion. Collecting data by questionnaire and interview, the target group is 170 students. The results indicate the most effective learning activity, value awareness, knowledge application and recommendation. The students' perception can be adopted for better activity in the future.

Keywords - *Heritage education, Architecture students, Learning activity, Heritage value, Sustainability*

I. INTRODUCTION

According to UNESCO, “heritage is our legacy from the past, what we live with today, and what we pass on to future generations”. Education is one of the main approaches that efficiently transfer heritage value and raises awareness in society, such as citizenship, cultural awareness, intercultural communication, sustainability, or historical thinking.Bangkok is facing rapid urban development in the last 30 years. Heritage buildings face urbanization. Some are conserved, some are adaptive reuse, some are abandoned and some are locally used. The conservation movement started in 1976. The committee was mainly academics and architects. Anyway, according to the Master Plan for Conservation and Development of Krung Ratanakosin 1997 and 2020, there are processing projects operating between Bangkok old town. Resulting in enriching the architectural knowledge, becoming a learning source for architecture students.Architecture education is practice in designing. Creativities and challenges are seen in the current exciting design. In the developing world, heritage buildings are potentially ignored. Instead, new high rise buildings or new urban structures are being constructed. According to this, architecture students need a wider perspective on the effects on heritage. Furthermore, as architecture is part of cultural heritage, there is more opportunity to be involved in design, not only in new buildings but also design with the value of heritage conservation mindset. Collaboration with ideas towards sustainable development, this educational aspect is one of the ways to achieve.

College of Architecture, SuanSunandhaRajabhat University(SSRU), was founded in 2018. There are 300 students. Students will visit several places throughout their bachelor program. These are chances for

students to explore by sight, experience space and perceive the atmosphere. Students experience heritage sites in different levels, such as monumental architecture, religious buildings and local communities. The location of the university is one of the important advantages for heritage study. The area is also surrounded by historic buildings which have changed their function and businesses that serve for modern use.

Moreover, as mentioned earlier, the trend of adaptive reuse building and new business needs architects who are able to manage and sustain the value of a heritage building. So value awareness and conservation knowledge or, ideally, cultural management is crucially important in architecture education.In order to integrate heritage knowledge into the courses through learning activities, the selected courses are architectural and historical value-based. Lecturers provide information about the value of the sites. In this study, it is to monitor the learning process and outcome through reflective comments from students. This created circular process will show results and adaptation over time.

II. METHODOLOGY

This study is survey research conducted in a mixed method, both qualitative and quantitative, which purposely understands how students perceive the value of heritage through learning activities.

2.1. Learning Activities

The experiment focused on 170 SSRU architecture students (BA) who were at different levels. They experienced all the activities in their 5-year program. The selected subjects are 1.Drawing and Presentation and 2. Thai Architecture and 3. Architecture Design in South East Asian countries, which have the potential to apply heritage study in learning activities. The 6 conducted activities were outdoor sketching, vernacular documentation, map making, site visit, Thai architecture model making and museum visit. They have been part of subjects annually in the last 5 years, although vernacular documentation was only conducted twice.

2.1.1 Outdoor sketching is part of the Drawing and

Presentation subject that is for 1st year level. These basic skills are both drawing and watercolor. Students have been in historical places with history and story explanation. This activity develops the interaction between students, objects and actual space by visual investigation.

Fig.1. Outdoor sketching

2.1.2 Site visit/field trip is a favorite activity that helps students learn from experience observation, which can be integrated into rapid surveys. Students take short notes and a few sketches.

2.1.3 Map making is the way to achieve the overall attribute or landscape, either showing in different scopes such as nation, urban, community scale. This is a part of Architecture Design in the South East Asian Countries. So, students have learnt a wide range of design and context from a regional perspective.

Fig.2. Map making

2.1.4 Vernacular Documentation is a technique of high quality architectural documentation with basic drafting tools. This is a direct process that can record the current condition of the architecture which could be in danger or any conservation requirement. The technique aesthetically demonstrates the value and authenticity of the architecture

Fig.3. Vernacular documentation.

2.1.5 Thai Architecture Model making - is a specific method that measures work plays the main role. Furthermore, model making needs a deep understanding of scale, proportion, components and material. The subject focuses on the value of Thai architecture.

Fig.4. Model making

2.1.6 Museum visits are rather close to site visits and field trips, but students turn to experience interpretation and exhibition management in order to learn the current interpretation of the site.

2.2 Target group and scope

The target group for this study is 170 bachelor degree architecture students at SuanSunandhaRajabhat University. These target groups vary in their levels, year 1-5. The heritage value in the study is a combination of 3 documents, namely.

Burra charter
Management Guidelines for World Cultural Heritage Site (Feilden and Jokilehto)
Annual report Sydney Barbour Foreshore Authority(2013)

There are 14 values related to architectural heritage applied in this study.

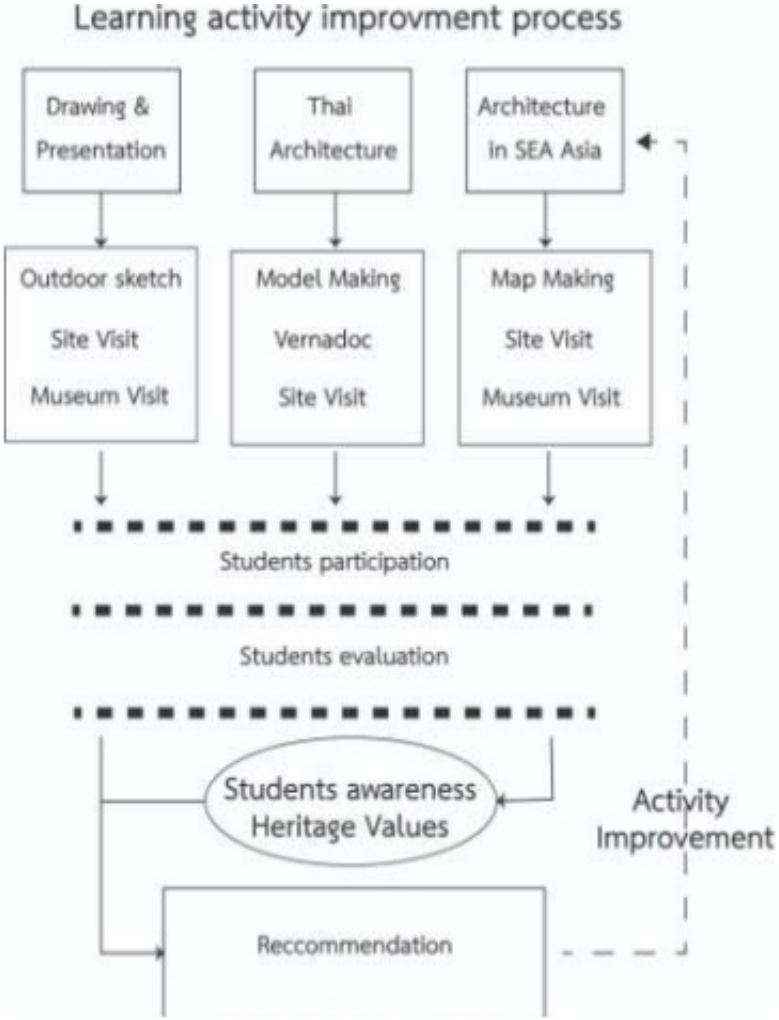


Chart.1: Study process

2.3. Data Collecting

In the participation of the target group in data collecting, the reflections firmly depend on individual experience. By doing this, a questionnaire was a way to collect reflections on each activity. The questions are to investigate the students' experience. By letting students select the most and the second most effective at showing heritage values. It is to understand whatpossibly the most effective activity students perceiveare. Students identified the value of the architectural heritage and engaged in giving recommendations on how to develop activity toward heritage learning.

III. RESULTS AND DISCUSSION

According to the survey, the top 2 learning activities that students considered the most and second effective are outdoor sketching and site visit, which have 62.5%. Secondly, museum visit activity is at 56.3%, followed by the Thai architecture model making 34.4%, map making and vernacular documentation 21.9% Regarding architectural value awareness, the result is historical value shows as common value among architecture students at 87%, identity and aesthetic is at 78%, education is at 65% and spiritual and social are at 59%, respectively. In addition, the survey collected the types of architecture that impress the learners the most. Local community sites are the most popular, religious

places and national historical monuments are the second and the
third are royal and governmental residences. All students agree that learning architectural heritage values is necessary for architecture students.

Table 1: Effectiveness of Activities by Students

Table2: Students Value Awareness

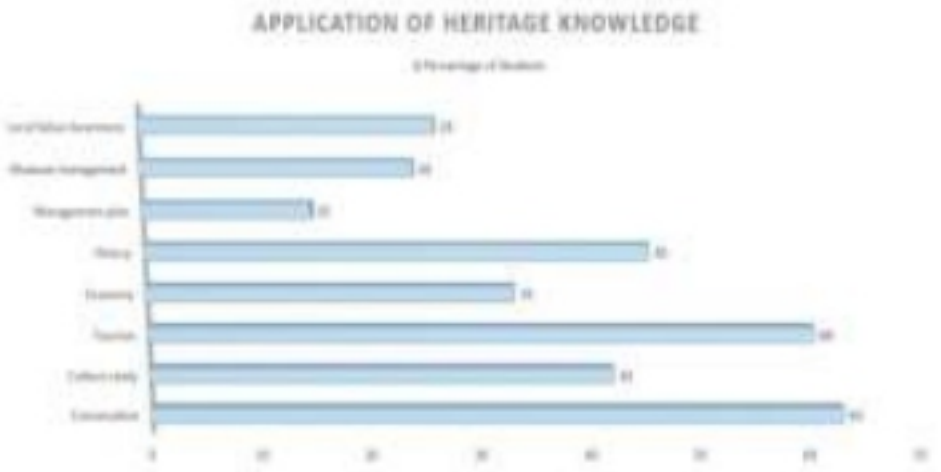


Table3: Application of Heritage Knowledge

All of the above are quantitative results. The survey also collects expected application of heritage knowledge and recommendations from students. It is found that students are likely to apply knowledge to conservation the most. Secondly, it is for tourism and cultural studies. The majority of recommendations are still on site visits and current experience. All selected activities are still functional. Apart from that, there are requirements for historical townscape study, storytelling by photo and architectural heritage exhibition. These findings can indicate opponents of future activities, according to a study.

IV. CONCLUSION

There are associations in data between the opinions. The effectiveness and recommendation of site visits that need support continuously support. The value awareness of students in historical value links to the application of knowledge in conservation. These 3 interconnections can imply projects. For example, architectural conservation and site visit. Importantly, students have more requirements for activities towards heritage study. In particular, the wider perspective at the urban level can be interpreted as a historical urban landscape. By doing this, students will learn at community levels by working in academic service, learning and developing with community work. Consequently, intangible heritage has become another topic of study. The learning activities will apply the result to future plans. Anyway, as long as positive satisfaction in all selected activities, the activities will be operate. The values such as function and economics are rather low, which can take into account learning activity. Even though there is no conservation course in the program, the perception of students has to develop a sub-course for conservation. In order to follow the trend of adaptive reuse, students will have a wide range in their professional lives. This study still has dimensions to monitor along with learning activities. The basic data will benefit by developing specific activity for each level of student. The further study plans to monitor the value perception change over time. Finally, it leads to promoting architectural conservation practice as a future opportunity for architecture students.

ACKNOWLEDGMENT

I would like to express my sincere thanks to College of Architecture, Suan Sunandha Rajabhat University and architecture students for valuable help throughout this study.

REFERENCE

[1] Australia ICOMOS Incorporated International Council on Monuments and Sites. (2013). The Burra Charter: The AustraliaICOMOS Charter for Places of Cultural Significance. Burwood, VIC 3125

[2] Chaparro-Sainz Á, Felices-De la Fuente MM, Rodríguez Medina J and Gómez-Carrasco CJ. (2022). Heritage Resources and Teaching Approaches. A Study With Trainee Secondary Education History Teachers. Front. Educ. 7:814197. doi: 10.3389/feduc.2022.814197

[3] Cole,J. (2019).What Architecture Students Need to Know about Heritage Studies.retrieved December 20,2022,from https://www.masterstudies.com/article/what-architecture students-need-to-know-about-heritage-studies/

[4] Cuenca-López, J.M., Martín-Cáceres, M.J. &Estepa Giménez, J. Teacher training in heritage education: good practices for citizenship education. HumanitSocSciCommun 8, 62 (2021). https://doi.org/10.1057/s41599-021-00745-6,

[5] Feilden. M, Jokilehto. J, (1998).Management Guidelines for World Cultural Heritge Site. (2 nd ed.). Italy. OGRARO.

[6] McKeown, R. (2006), Education for Sustainable Development Toolkit. France. UNESCO's workshop.retrieved January 22,2023 from https://shorturl.asia/tk8bv

[7] Office of Environmental Policy and Planning. (2021). Masterplan of Conservation and Development of Krung Rattanakosin..Bangkok, Chula Unisearch,Retrieved November15, 2022, from https://pubhtml5.com/sktj/mydo

[8] Petti, Luigi, Claudia Trillo, and BusisiweNcubeMakore. 2020. Cultural Heritage and Sustainable Development Targets: A Possible Harmonisation? Insights from the European Perspective.Sustainability 12, no. 3: 926. https://doi.org/10.3390/su12030926

[9] Sydney Barbour Foreshore Authority, (2013-14), Annual Report 2013, Austraria, Sydney Barbour Foreshore Authority

[10] The Group for Education in Museums (GEM), The value of heritage education, retrived November 25,2022 from https://gem.org.uk/our-work/value-of-heritage-education/

[11] UNESCO. (2022). What you need to know about education for sustainable development, retrieved November 23, 2022from https://www.unesco.org/en/education/sustainable development/need-know#what-is-education-for-sustainabledevelopment-

[12] UNESCO. (2017).Education for Sustainable Development GoalsLearning ObjectivesEducation for Sustainable Development Goals: Learning Objectives. France, UNESCO,retrieved December 15,2022 from https://shorturl.asia/shHnm

[13] UNESCO.(2020). Intangible Cultural Heritage, Sustainable development and living heritage. retrieved January 18, 2023 from https://ich.unesco.org/en/sustainable-development-and living-heritage

[14] UNESCO Office for the Pacific States. (2016). IntangibleCulturalHeritage and the SustainableDevelopment Goals in thePacific. Retrieved November 12, 2022 from https://unesdoc.unesco.org/ark:/48223/pf0000245796

[15] UNESCO World Heritage Centre. (2008).World Heritage Information Kit. France, UNESCO World Heritage Centre. Retrieved December 15, 2022 from https://whc.unesco.org/en/activities/567/

[16] Van Doorsselaere, J. (2021). Connecting Sustainable Development and Heritage Education? An Analysis of the Curriculum Reform in Flemish Public Secondary Schools. Sustainability, 13(4), 1857. MDPI AG.http://dx.doi.org/10.3390/su13041857

ISSN: 2394-2827

DESIGN OF RECTANGULAR INDETERMINATE BEAMS USING PYTHON

1CHANDRAKANTH MANDAVA, 2 SUNEEL ABBIREDDY, 3ALEKHYA GODITHI

Department of Civil Engineering, Sir C R Reddy College of Engineering, Eluru, Permanently Affiliated to JNTU Kakinada

ABSTRACT

The analysis and design of a beam became tedious while calculating by hand methods, it became a time consuming process. To minimize this, many software are introduced into the market, which makes the whole process easy. But the main drawback is that there is no place for analysis/design for economic sections, i.e., the software only provides the outputs for the given inputs, which is not automated. Through this paper, we discuss a program which is developed using the "Python" language. The program firstly gives the economic section dimensions based on the applied load and other characteristics (mainly concerned about the deflection criteria), and later on analysis/design along with the report prepared with the program. The whole process is done on any device, making it universal, even a mobile with basic features can run this program. This program is free open-source for all and can be modified if required. As computers continue to grow in capability, it is the purpose of this paper to consider the role of computational methods and how they may empower present and future structural Engineers.

Keywords *– Python Programming, Finite Element Method, Interactive Design, Statistical Model,Structural Response.*

I. INTRODUCTION

Nowadays, machinery (either the physical/hardware or the software) are mingled with human life in such a way that without the use of machinery, people cannot lead their life, not only for comfort and luxury but even for an ordinary and simple life. In practice, some types of machinery are operated as "stationary machinery," i.e., working in the same places, such as rice mills, flour mills, windmills, and machine tools like lathes, milling machines, planning machines, and so on. Similarly, some other types of machinery are working as "mobile type," i.e., moving from place to place, such as all vehicles like automobiles, trains, ships, aircraft, etc. All the above-specified types of machinery contain moving parts. Some fabricated items do not have movable parts and are usually represented as 'structures.' For example, trusses, beams, etc. When they are applied by some external loads, their parts will be deformed, i.e., a change of dimensions will occur in the loaded parts. During loading, the structure or machine will exist if the deformed dimensions (i.e., displacements) are within the permissible limits. Otherwise, they will be fractured, which results in their functional failure. To find out the values of deformations (i.e., change of dimensions), various techniques are employed. These techniques used for finding the change

of dimensions and induced stresses due to applied loads in various parts are generally referred to as 'Engineering analyses.' In practice, different types of analyzing methods are adopted. Depending upon the size of machinery, such as small or big, and the nature of its shape, such as simple or complicated, etc.

A suitable method can be employed. For analyzing structures, the structural analysis approach is used.

The methods of structural analysis have been dramatically revolutionized by the advance in digital computers and the demand is stringent design requirements. Several significant milestones are:

In the 1940s, Hardy Cross first proposed the moment distribution method, based on the relaxation concept, to solve large system so find eterminate frame structures

. In the 1940s and 1950s, structural engineers were challenged with the highly statically indeterminate systems, due to the development of high-rise buildings and structures across the globe.

In the 1950s, a group of structural engineers Turner Clough, Martin and Top at Boeing Company also proposed the matrix formulation for structural analysis for aero planes.

Since the 1950s itself, digital computers have been rapidly initiated.

In 1954, Professor J. Argyris and S. Kelsey proposed the matrix method of structural analysis, which is a computer-based application.

Furtherly, a generalized computer method i.e., The Finite Element Method (F.E.M) was developed for conducting structural analysis of a wide variety of structures.

Both the computer and classical methods are established from the fundamental principles of mechanics of materials. They are the Force equilibrium method or energy balance of structure. This paper has concluded the analysis and design of indeterminate beams/horizontal members Beams are the horizontal members probably known as the "Secondary Transverse Structural member" of any structure we see in real life, they are designed to resist horizontal loads like imposed floor loads, imposed dead loads, accidental loads, sudden loads, and self-weight, etc. On the other hand, the Reinforced Cement Concrete beams resist the loading by the action of bending, hence they are designed based on the limit state of collapse in flexure, limit state of shear, limit state of torsion (wherever required), limit state of the bond.

Generally, beams are of many types majorly classified as two based on determinacy, i.e., statically determinate and statically indeterminate. In this paper, we discussed the beams other than cantilever beam (which is easy to analyze) like simply supported, propped cantilever, continuous, and fixed beams.

The following flowchart describes the whole process of the code written.

Python is the primary step for this project. Python is a powerful high-level programming/scripting language, designed by Guido Van Rossum in 1991. Later, it was developed by the "Python Software Foundation". It is open-source software and the documentation is also available from its website, where users browse to the website and download the necessary software version which is compatible with their personal computers (Pcs), Desktops, Mac, etc.

The Python documentation focuses on learning Python to do mathematical calculations. It is a simple programming language. When we read the Python program, we feel like reading English statements. The syntaxes are very simple and only 30+ keywords are available. When compared with other languages, we can write programs with a smaller number of lines. Hence, more readability and

simplicity. We can also reduce the development time and cost of the project. A Python program, once written, can be compatible without rewriting again. The entire load is taken by the PVM (Python Virtual Machine) which converts it to machine language (Binary language). Perhaps we can say it as the system's hardware and software combinedly will do the necessary operation.

While analyzing beam(s), there are many methods, but for automation techniques, the method adopted here is the Finite Element Method (F.E.M). As the concept of F.E.M is suitable for computers, the exact method for getting accurate results. While designing beam(s), a similar way, i.e., conventional codal design procedure, is considered and the program is written accordingly. Interactive with user. Preparing of plot is much easier in this case than matplotlib. By combining the above modules, we developed a program which gives a step-by-step detailed report of analysis and design of the corresponding section. Out of five thousand randomly developed designs, only one is chosen as the best design for the problem statement.

II. PYTHON MODULES

There are many modules in Python which are very helpful for complex calculations, some of them are: NumPy, SciPy, Seaborn, and PyLab.

"NumPy" is probably the most important library, and most of the other libraries are built using NumPy. It helps in creating multi-dimensional arrays with ease. For example, if we have to interpolate the design strength of steel based on the grade of steel, this data is given in table A (clause 1.4) of SP 16-1980. With the use of NumPy, these arrays can be used in programming for further calculations.

"SciPy" is another important library which is extensively used for bulky, tedious calculations. For example, if we have to interpolate values from the code, and this interpolation in the design of reinforced concrete structures is mostly one dimensional, the SciPy function "interp1d" performs such interpolations for a user value in the program from a given NumPy array. SciPy can also be used for performing numerical integration, solving differential equations, etc.

"Pandas" is another important library that gives access to using MS-Excel in programming, as most of the Civil Engineering works involve large data and are handled with MS-Excel spreadsheets.Any problem without data visualization is very hectic in nature to understand and deliver the concept, but Python has some popular data visualization tools like Matplotlib, Pyplot, etc. "Matplotlib" is the library for plotting multiple types of 2D graphs using Python. It can produce high-quality bar charts, histograms, power spectra, etc.

"Pyplot" is another module that has gained popularity in recent times as it looks like an updated version of the Matplotlib module. The main difference is that the graphs plotted are very much.

III. METHODOLOGY

Design of beams generally follow a step-by-step processwithnecessarychecksusingIS456-200.Thestepwiseprocedure can be tedious in manual way due to mis calculationsanderroneousassumingof data.

A well checked well written algorithm consisting various design procedure along with checks is developed by python language. A use interface is created where interaction with the computer is done by giving appropriate inputs

IV. RESULTS

Figure2:beamdesigncalculator

Beams	Areaofsteel		ACCURACY (%)
	theoretical	programming	
BEAM1	280.099	279.847	99.91
BEAM2	672.045	671.844	99.97
BEAM3	981.281	981.084	99.98

Figure3:resultcomparisonforsinglyreinforcedsections

V. CONCLUSION

The principal goal in the design of any general engineering structure is to achieve stability. A structure must remain stable and therefore, fit for purpose, throughout its utility period. This requirement can be achieved with the help of structural analysis and design techniques, which nowadays can be performed using computers. The significance of the results is determined during the interpretation phase and the engineer either decides that stability can be achieved or works through the process again, modifying the initial idealization.

ACKNOWLEDGEMENT

I take the opportunity to express a profound thanks and a deep sense of gratitude to the Head of the Department, Mr. C. Ramesh Dutt, and to my guide, Mr. Mandava Chandra Kanth, Assistant Professor, Department of Civil Engineering, who permitted me to carry out this project work under his able

guidance. Their keen interest, guidance, and sustaining encouragement have always been inspiring. I express my deep-seated sense of obligation to him as he made it possible for us to submit the thesis in the present form.

REFERENCE

[1] IS456-2000plain and rein forced concrete–code of practice [ced2:cement and concrete].
[2] IS875(part1)(1987,reaffirmed2008):codeofpracticefordesign loads(other than earthquake)for building and structures.Part1:deadloads–unit weights of building materials and stored materials (second revision).Udc624.042: 006.76
[3] IS 875 (part 2) (1987, reaffirmed 2008): code of practice for designloads (other than earthquake) for buildings and structures. Part 2:imposedloads (secondrevision).Udc624.042.3:006.76
[4] Design and Detailing of Rein forced Concrete Structures by M.R Dheerendhra Babu, Falcon publishers
[5] Applicability of pythoni n civil engineering: reviewmr. Arshadquraishi,mr. N.K. Dhapekare-issn:2395-0056,p-issn:2395-0072.
[6] Python-based computational platform to automate seismic design,nonlinear structural model construction and analysis of steel momentresist ingframes by Xingquan Guan,HenryBurton, ThomasSabol.
[7] Finite Element Analysis in engineering by Md.Jalaludeen.
[8] Structuralanalysis amatrixapproachbyG.S.Pandit,S.P.Gupta
[9] Mcgrathm.(2018),pythonineasysteps,2013edition, ninthreprint, mcgrawhilleducation pvt.Ltd, chennai.
[10] FiniteElementAnalysisbyS.S.Bhavikatti.
[11] https://colab.research.google.com/?utm_source=scs-index
[12] https://colab. research. google.com /notebooks/ basic_features _overview.ipynb
[13] Guidovan Rossum ,Python Tutorial, http://docs.python.org/
[14] Guido van Rossum, Python Library Reference Manual,http://docs.python.org/
[15] https://www.datacamp.com/community/tutorials/datascience-python-ide
[16] https://docs.python.org/3/library/index.html#library-index
[17] https://pandas.pydata.org/
[18] https://docs.scipy.org/doc/scipy/reference/

Instructions for Authors

Essentials for Publishing in this Journal

1 Submitted articles should not have been previously published or be currently under consideration for publication elsewhere.

2 Conference papers may only be submitted if the paper has been completely re-written (taken to mean more than 50%) and the author has cleared any necessary permission with the copyright owner if it has been previously copyrighted.

3 All our articles are refereed through a double-blind process.

4 All authors must declare they have read and agreed to the content of the submitted article and must sign a declaration correspond to the originality of the article.

Submission Process

All articles for this journal must be submitted using our online submissions system. http://enrichedpub.com/ . Please use the Submit Your Article link in the Author Service area.

Manuscript Guidelines

The instructions to authors about the article preparation for publication in the Manuscripts are submitted online, through the e-Ur (Electronic editing) system, developed by **Enriched Publications Pvt. Ltd**. The article should contain the abstract with keywords, introduction, body, conclusion, references and the summary in English language (without heading and subheading enumeration). The article length should not exceed 16 pages of A4 paper format.

Title

The title should be informative. It is in both Journal's and author's best interest to use terms suitable. For indexing and word search. If there are no such terms in the title, the author is strongly advised to add a subtitle. The title should be given in English as well. The titles precede the abstract and the summary in an appropriate language.

Letterhead Title

The letterhead title is given at a top of each page for easier identification of article copies in an Electronic form in particular. It contains the author's surname and first name initial .article title, journal title and collation (year, volume, and issue, first and last page). The journal and article titles can be given in a shortened form.

Author's Name

Full name(s) of author(s) should be used. It is advisable to give the middle initial. Names are given in their original form.

Contact Details

The postal address or the e-mail address of the author (usually of the first one if there are more Authors) is given in the footnote at the bottom of the first page.

Type of Articles

Classification of articles is a duty of the editorial staff and is of special importance. Referees and the members of the editorial staff, or section editors, can propose a category, but the editor-in-chief has the sole responsibility for their classification. Journal articles are classified as follows:

Scientific articles:

1. Original scientific paper (giving the previously unpublished results of the author's own research based on management methods).

2. Survey paper (giving an original, detailed and critical view of a research problem or an area to which the author has made a contribution visible through his self-citation);

3. Short or preliminary communication (original management paper of full format but of a smaller extent or of a preliminary character);

4. Scientific critique or forum (discussion on a particular scientific topic, based exclusively on management argumentation) and commentaries. Exceptionally, in particular areas, a scientific paper in the Journal can be in a form of a monograph or a critical edition of scientific data (historical, archival, lexicographic, bibliographic, data survey, etc.) which were unknown or hardly accessible for scientific research.

Professional articles:

1. Professional paper (contribution offering experience useful for improvement of professional practice but not necessarily based on scientific methods);
2. Informative contribution (editorial, commentary, etc.);
3. Review (of a book, software, case study, scientific event, etc.)

Language

The article should be in English. The grammar and style of the article should be of good quality. The systematized text should be without abbreviations (except standard ones). All measurements must be in SI units. The sequence of formulae is denoted in Arabic numerals in parentheses on the right-hand side.

Abstract and Summary

An abstract is a concise informative presentation of the article content for fast and accurate Evaluation of its relevance. It is both in the Editorial Office's and the author's best interest for an abstract to contain terms often used for indexing and article search. The abstract describes the purpose of the study and the methods, outlines the findings and state the conclusions. A 100- to 250-Word abstract should be placed between the title and the keywords with the body text to follow. Besides an abstract are advised to have a summary in English, at the end of the article, after the Reference list. The summary should be structured and long up to 1/10 of the article length (it is more extensive than the abstract).

Keywords

Keywords are terms or phrases showing adequately the article content for indexing and search purposes. They should be allocated heaving in mind widely accepted international sources (index, dictionary or thesaurus), such as the Web of Science keyword list for science in general. The higher their usage frequency is the better. Up to 10 keywords immediately follow the abstract and the summary, in respective languages.

Acknowledgements

The name and the number of the project or programmed within which the article was realized is given in a separate note at the bottom of the first page together with the name of the institution which financially supported the project or programmed.

Tables and Illustrations

All the captions should be in the original language as well as in English, together with the texts in illustrations if possible. Tables are typed in the same style as the text and are denoted by numerals at the top. Photographs and drawings, placed appropriately in the text, should be clear, precise and suitable for reproduction. Drawings should be created in Word or Corel.

Citation in the Text

Citation in the text must be uniform. When citing references in the text, use the reference number set in square brackets from the Reference list at the end of the article.

Footnotes

Footnotes are given at the bottom of the page with the text they refer to. They can contain less relevant details, additional explanations or used sources (e.g. scientific material, manuals). They cannot replace the cited literature.
The article should be accompanied with a cover letter with the information about the author(s): surname, middle initial, first name, and citizen personal number, rank, title, e-mail address, and affiliation address, home address including municipality, phone number in the office and at home (or a mobile phone number). The cover letter should state the type of the article and tell which illustrations are original and which are not.

Note