Feasibility study on application of ready mix concrete in construction projects in Nepal

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Abstract
Ready mix concrete (RMC) is a new concreting concept in the Nepali construction industry introduced before one decade. The paper aims to assess the acceptance of ready mix for residential buildings of Nepal. The relation was developed for average compressive strength with slump value and water cement ratio based on laboratory test nominal mix M20 (1:1.5:3) and M25 (1:1:2) along with questionnaire survey. The result also shows that the compressive strength of RMC is higher in comparison with the SMC (site mix concrete). During questionnaire, more than 60% of users prefer the RMC over SMC. The merit and demerit of construction projects using RMC and SMC are discussed and interpreted.

Keywords Strength · Ready mix · Ordinary concrete · Cost variations · Acceptance · Green marketing

Introduction
Concrete is most widely used as construction material in place of brick work or reinforced brick. It is used in the construction of heavy structures like dams, reservoirs, multistory buildings, bridges, flyovers, and runways, etc. Concrete can be used in foundations, superstructures, partitions, slabs, etc. (Shetty 2000; Dua 2013). Ordinary concrete is a homogeneous combination of cement, sand, and stone chips that is cast using sufficient water. All of the raw elements for concrete, such as cement, sand, and stone chips, are measured out and placed in the proper proportions in a plain sheet or brick soling, where they are mixed by hand first in a dry state, and then enough water is added to form an usable concrete.

Materials and methods
Research approach
The process of preparing the mix is called ordinary concrete mix (Rao 2013). But in case of normal concrete it is mixed in the site of work. This type of concrete is also known as in situ concrete mix. Preparation of concrete is a controlled process, and different grades of concrete can be prepared as per requirement or site conditions (Hager et al. 2020; Abousnina et al. 2020). In the construction practices in Nepal, both the readymade and ordinary concretes are used (Matarul et al. 2016; Mishra and Umesh, 2018). In this regard, ready mix concrete is produced in controlled way in factory and ordinary concrete is produced in situ by local practice and hand mix. This study is for the comparison between these concrete (Shah et al. 2014).

The goal of the study is to undertake a limited investigation, focusing on samples obtained from the field four construction sites of Kathmandu Valley, in order to conduct the proposed work in selected construction site. The aim of the study is to assess the acceptance of readymade concrete effectiveness, strength in response to ordinary concrete among user for 20MPA and 25MPA grades (Shahi, 2013).
test of different site of Kathmandu Valley. Both qualitative and quantitative approaches of research were used (Yadav et al. 2017).

**Study area**

The secondary data were collected from different construction site for the Kathmandu Valley (Fig. 1). The primary data analysis is from: (a) Construction of Auditor General Building supreme audit institution of Nepal, (b) Construction of Nepal Army Head Quarter Building, Bhadrakali, (c) Commercial Building for Sushil Gupta at Kupondole, Lalitpur, and (d) Residential Building for Bishnu Agrawal at Sanepa, Lalitpur (RMC, 2010).

**Conceptual frame work**

Conceptual frame work of the study is shown in Fig. 2.

**Study population**

In this study, the targeted population was the different type of buildings of Kathmandu Valley. The total samples used in the study are 72 numbers for compressive strength test (for laboratory test) and 24 samples for slump test (field test). The samples for laboratory tests include 36 samples from three batches of M20 and M25 concrete formed by ready mix concrete from the site: a) Auditor General Building supreme audit institution of Nepal and b) Nepal Army Head Quarter Building, Bhadrakali. The remaining 36 samples are taken by site mix concrete of three batches of M20 and M25 concrete from the site: a) Commercial Building for Sushil Gupta at Kupondole, Lalitpur and b) Residential Building for Bishnu Agrawal at Sanepa, Lalitpur. The field test was carried out by slump test which includes 12 samples for RMC and 12 samples for SMC. The samples were collected according to IS 456 2000 as Sampling and Strength of Designed Concrete Mix (IS 456, 2000).

**Sample selection**

The typical samples were chosen based on visual identification of a suitable RMC and SMC, as well as a variety of samples collected from different places. For the study, 96 samples were collected which includes: a) cube test: 36 samples for RMC, 36 samples for SMC and b) slump test: 24 samples for both RMC and SMC (IS 456, 2000).

**Data collection/analysis**

**Field test**

The slump test was carried out from \(4 \times 3 \text{(M20)} + 4 \times 3 \text{(M25)}\) 24 numbers of concrete mix. Slump test results were achieved in the site using test mould for slump test: non-porous base plate, measuring scale, tamping rod (IS 456, 2000).

**Questionnaire survey**

The questionnaire sheet includes 23 numbers of question, from each selected site five personnel was asked to answer the question (Appendix).

**Laboratory test**

Based on the samples retrieved from the sites, laboratory tests on the 72 samples were conducted in the Central Army Head quarter Building, Bhadrakali

Residential Building, Sanepa

Commercial building, Kupandole

Auditor General Building, Anamnagar

Fig.1 Location map of construction site in Kathmandu Valley
Material Testing Laboratory of Institute of Engineering, Pulchowk. Laboratory test was performed on the data collected from primary source. The compressive strength tests have been performed from the samples collected. Laboratory compressive strength value from primary data was observed from laboratory test (Shetty 2000).

The above-mentioned tests, compressive strength from the cube which were casted from each site of three number of batch, i.e., \((4 \times 3 \times 3)\) (M20, 28 days) + \(4 \times 3 \times 3\) (M25, 28 days) 72 no of cube samples (IS 456, 2000).

data analysis

a) Slump test is conducted in field to find workability value.

b) Arbitrary value of mix design was taken which is already done by contractor.

c) Mixing of concrete was done by taking the required amount of ingredient from their site.

d) Ordinary Portland cement was used from their site, and minimum grade was 25MPA

e) Slump test (IS: 1199 – 1959).

f) Cost comparisons of RMC and SMC (Allan 2006).

Rate of SMC and RMC as per government norms and district rate is shown in Table 1.

Results and discussion

Strength of RMC and SMC by laboratory test and results

The result obtain based on the ages shows that the strength for RMC is uniform and meets nearly as design strength,
whereas in SMC, the result found more variance with respect to design concrete strength (Haq et al. 2013; Nadupuru 2015). And the result shows that more W/C ratio leads to low compressive strength and low porosity. This may be due to the cause that the lower water/cement ratio has stronger compression strength than the larger water/cement ratio, according to the results (Chaudhari et al. 2014).

Table 2 shows the compressive strength test of the samples at 28 days of casting obtained from the Auditor General Building. The test results show that the compressive strength of the concrete of batch 3 at M20 is higher, whereas that of the batch 1 at M25 is higher.

Table 3 shows the compressive strength test of the samples at 28 days of casting obtained from the Army Head Quarter. The test results show that the compressive strength of the concrete of batch 1 at M20 is higher, whereas that of the batch 3 at M25 is higher.

Table 4 shows the compressive strength test of the samples at 28 days of casting obtained from the commercial building of Sushil Gupta. The test result shows that the compressive strength of the concrete of batch 3 at M20 is higher, whereas the batch 1 at M25 is higher (Suryakanta 2015).

Table 5 shows the compressive strength test of the samples at 28 days of casting obtained from the residential building of Bishnu Agrawal. The test results show that the compressive strength of the concrete of batch 3 at M20 is higher, whereas the compressive strength test of the concrete of batch 3 at M25 is higher.

### Plot of average strength of concrete and slump or water cement ratio

The graph of average strength of concrete of different grade with different slump and water cement ratios (w/c) is obtained as shown in Fig. 3. Similarly, strength of concrete was taken for RMC and SMC/OC.

Figure 3 shows the relation established between the average strength and slump value. In Fig. 3, the minimum strength is found at 155 mm slump and maximum strength at the slump value at 80 mm. The best fit line equation was $\text{Avg. Str.} = -0.007 \times \text{slump} + 23.58$ having $R^2$ value $R^2 = 0.757$. The graph shows the slump value 80 mm gained the best strength result.

Figure 4 shows the relation established between the average strength and slump value. In Fig. 4, the minimum strength

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**Table 2** Slump test and compressive strength test for site 1

| Code | B1-20 | B1-20 | B1-20 | B1-25 | B1-25 | B1-25 |
|------|-------|-------|-------|-------|-------|-------|
| Section | Raft | Raft | GFSlab | GF Column | GF Column | FF Column |
| Casting Date | 11/5/2074 | 11/6/2074 | 1/5/2075 | 11/28/2074 | 11/29/2074 | 1/24/2075 |
| Testing Date | 12/3/2074 | 12/4/2074 | 2/20/2075 | 12/26/2074 | 12/27/2074 | 2/21/2075 |
| Nominal ratio | 1:1.5:3 | 1:1.5:3 | 1:1.5:3 | 1:1:2 | 1:1:2 | 1:1:2 |
| W/C | 0.45 | 0.48 | 0.46 | 0.42 | 0.43 | 0.44 |
| Slump(mm) | 80 | 155 | 145 | 135 | 140 | 146 |
| S1 | 2.19 | 2.19 | 2.06 | 3.07 | 2.85 | 2.41 |
| S2 | 2.28 | 2.15 | 2.54 | 3.11 | 3.07 | 2.59 |
| S3 | 2.41 | 2.32 | 2.19 | 3.02 | 2.85 | 2.54 |
| Avg. strength(KN/cm²) | 2.29 | 2.22 | 2.26 | 3.07 | 2.92 | 2.51 |

**Table 3** Slump test and compressive strength test for site 2

| Code | B2-20 | B2-20 | B2-20 | B2-25 | B2-25 | B2-25 |
|------|-------|-------|-------|-------|-------|-------|
| Section | 3F-Slab | 3F-Slab | 4F-Slab | 3F-Column | 4F-Column | 4F-Column |
| Casting Date | 12/8/2074 | 12/9/2074 | 2/6/2075 | 1/15/2074 | 1/27/2075 | 1/28/2074 |
| Testing Date | 1/6/2075 | 1/7/2075 | 3/3/2075 | 12/13/2074 | 2/24/2075 | 2/25/2074 |
| Nominal ratio | 1:1.5:3 | 1:1.5:3 | 1:1.5:3 | 1:1:2 | 1:1:2 | 1:1:2 |
| W/C | 0.45 | 0.46 | 0.48 | 0.43 | 0.44 | 0.45 |
| Slump(mm) | 145 | 155 | 160 | 148 | 150 | 152 |
| S1 | 2.19 | 2.10 | 1.75 | 2.59 | 2.76 | 2.85 |
| S2 | 1.84 | 2.02 | 2.08 | 2.72 | 2.85 | 3.07 |
| S3 | 2.15 | 2.02 | 1.97 | 2.80 | 3.02 | 2.85 |
| Avg. strength(KN/cm²) | 2.06 | 2.05 | 1.94 | 2.70 | 2.88 | 2.92 |
is found at 146 mm slump and maximum strength at the slump value at 135 mm. The best fit line equation was \[ \text{Avg. str.} = -0.510 \times \text{Slump} + 99.97 \] having R\(^2\) value \( R^2 = 0.954 \). The graph shows the slump value 135 mm was the best strength result.

Figure 5 shows the relation established between the average strength and water cement (w/c) ratio value for 20 MPa concrete (Omotola and Idowu 2011). In Fig. 5, the minimum strength is found at 0.48 w/c and maximum strength at the w/c value at 0.45 The best fit line equation was \[ \text{Avg. str.} = -23.99 \times \text{w/c} + 33.71 \] having R\(^2\) value \( R^2 = 0.994 \). The graph shows the w/c value 0.45 was the best strength result.

Figure 6 shows the relation established between the average strength and water cement ratio value for 25 MPa concrete.
In Fig. 6, the minimum strength is found at 0.44 w/c and maximum strength at the w/c value at 0.42. The best fit line equation was \( \text{Avg. str.} = -277.5 \times \text{w/c} + 147.6 \) having \( R^2 = 0.930 \). The graph shows the water cement ratio (w/c) value 0.42 was the best strength result (Paul 2016; Lee et al. 2020).

**Army head quarter building**

For Army Head quarter building, the relation was established between the average strength and slump value for 20 MPa concrete where the minimum strength is found at 160 slump and maximum strength at the 145 slump. The best fit line equation was \( \text{Avg. str.} = -0.620 \times \text{slump} + 21.37 \) having \( R^2 = 0.836 \), whereas for M25 MPa the minimum strength is found at 140 mm slump and maximum strength at the slump value at 145 mm. The best fit line equation was \( \text{Avg. str.} = -2.775 \times \text{slump} + 33.88 \) having \( R^2 = 0.930 \) Fig. 7. The graph assessment shows the slump value 125 mm was the best strength result (Kim 2009).

This relation was established between the average strength and water cement (w/c) ratio value for 20 MPa concrete where the minimum strength is found at 0.48 w/c and maximum strength at the w/c value at 0.45. The best fit line equation was \( \text{Avg. str.} = -0.620 \times \text{w/c} + 21.37 \) having \( R^2 = 0.836 \). The graph assessment shows the w/c value 0.45 was the best strength result. Similarly, the relation was established between the average strength and water cement ratio value for 25 MPa concrete where the minimum strength is found at 0.43 w/c and maximum strength at the w/c value at 0.45. The best fit line equation was \( \text{Avg. str.} = 1.095 \times \text{w/c} + 26.14 \) having \( R^2 = 0.892 \). The graph assessment shows the water cement ratio (w/c) value 0.45 was the best strength result (Titarmare et al. 2012).

**Commercial building**

The relation was established between the average strength and slump value for 20 MPa concrete at commercial building where the minimum strength is found at 85 slump and maximum strength at the 123 slump. The best fit line equation was \( \text{Avg. str.} = 1.168 \times \text{Slump} + 18.50 \) having \( R^2 = 0.531 \). The graph assessment shows the slump 123 gained the best strength result.

This relation was established between the average strength and slump value. In Fig. 4, 10 the minimum strength
R2 = 0.531. While the graph was plotted, it was seen that the equation was Avg. str. = 1.168*w/c + 18.50 having R2 value maximum strength at the w/c value at 0.49. The best fit line equation was Avg. str. = 1.168*w/c + 18.50 having R2 value R2 = 0.531. While the graph was plotted, it was seen that the w/c value 0.49 was the best strength result.

The relation was established between the average strength and water cement ratio (w/c) value for 20 MPa concrete. In Fig. 4.11, the minimum strength is found at 0.48 w/c and maximum strength at the w/c value at 0.49. The best fit line equation was Avg. str. = −1.679*w/c + 31.26 having R2 value R2 = 0.782. The water cement ratio (w/c) value 0.43 was the best strength result. (Manjunatha et al. 2015; Domagala 2020).

Residential building

In the residential building site, the relation was established between the average strength and slump value for 20 MPa concrete with the minimum strength found at 135 slump and maximum strength at the slump value at 128. The best fit line equation was Avg. str. = 1.972*slump + 20.98 having R2 value R2 = 0.883. It was seen that the slump 128 was the best strength result.

The relation was established between the average strength and water cement ratio (w/c) value for 25 MPa concrete. In Fig. 4.12, the minimum strength is found at 0.42 w/c and maximum strength at the w/c value at 0.43. The best fit line equation was Avg. str. = −1.679*w/c + 31.26 having R2 value R2 = 0.782. The water cement ratio (w/c) value 0.43 was the best strength result (Manjunatha et al. 2015; Domagala 2020).

Cost comparison

The SMC unit price rate as per Government of Nepal, Department of Building, is NRs 18,381.00/M³ for M20 and NRs 22,425.00/M³, for M25, while that of the RMC is NRs 14,500.00/M³ for M20 and NRs 15,500.00/M³, for M25. The RMC rates are below the government norms. These prices yield a difference of about 26 and 45% for M20 and M25 between RMC and SMC; SMC is higher than the upper limit recorded in Nepal (Magudeaswaran and Eswaramoorthi 2013). A typical intended concrete compressive strength of 25 MPa is sought by over half of the sample, whereas only about 10% seek a compressive strength of 25 MPa or greater. According to Allen (2006), this could also result in demand fluctuation.

User acceptance

Price, according to the experts interviewed, is likely the most significant barrier to RMC adoption in the Nepali market. The reader is advised to distinguish between unit pricing and overall cost in this regard. They also stated that the majority of Nepalese clients wrongly believe that the unit pricing represents the overall cost. To avoid the “apparent” price difference between RMC and SMC, the average customer usually opts for the latter, regardless of the design and construction implications that ultimately result in direct savings (Shahi 2013). Customers’ perceptions and awareness of RMC qualities, according to the experts, are equally important. They pointed out that RMC’s small presence in the building industry is due to three characteristics that characterize the local market: reluctance to change, a lack of market motive, and a lack of confidence among concrete practitioners. (Mannan and Idris 2013).

It should be mentioned that, regardless of concrete type, it is normal, albeit erroneous, in the local market to design residential buildings at an average nominal compressive strength of 25 MPa (Omotola and Idowu 2011). As a result, when RMC is utilized, the structural design does not take advantage of its greater strength. When it comes to customer satisfaction with RMC quality, it appears to be fairly high. During the questionnaire, approximately three quarters of the participants expressed satisfaction with RMC. Jain (2017) shows prospects of RMC and the same could be reviled from the questionnaire as 61% of the respondents were satisfied with uses of RMC regarding strength and cost. A smaller group representing 29% of the respondents were dissatisfied with RMC. A much smaller group amounting to 10% of the respondents were willing to adopt both of two. Surprisingly, three quarters of the participants (almost the sum of the previous three groups of participants) would adopt RMC for greater quality, service, and sustainability in the construction business.

Limitations

It will be difficult to collect large number of samples including geographical areas in Nepal for overall country and hence will be focused in the study area.
Conclusion

The following conclusions are drawn from the comparative study of RMC and OC.

- The average strength and slump for grade M20 and M25 of Auditor General and Nepal Army Head quarter Building which was RMC was slump average slump value 80 and 145 mm, respectively, and its pave the consistency in strength and value of slump was close.
- The average strength and water cement ratio of grade M20 and M25 of Auditor General and Nepal Army Head quarter Building which was RMC was average water cement ratio value 0.45 and 0.45, respectively, and the consistency in strength and value of w/c was close.
- It is evident that average strength and slump for different grade M20 and M25 of commercial and residential building which was OC was slump average slump value 124 and 127 mm, respectively, and so the consistency in strength and value of slump was wider than the RMC.
- In same way, average strength and water cement ratio for different grade M20 and M25 of commercial and residential building which was OC was W/C average w/c value 0.43 and 0.46 mm, respectively, and it narrated the consistency in strength and value of slump was wider than the RMC.

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Declarations

Conflict of interest

The authors have no conflict of interest.

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