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Truck Planning and Daily Work Targets in Highway Construction

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ABSTRACT
Road construction needs a steady supply of materials from the mixing plant to the site. This study examined how the daily work length and number of trucks related to material deliveries for granular sub-base and wet mix macadam. Records from 62 highway projects included 60 observations for each of these two road layers. An Arena computer model followed the movement of materials and equipment. A Taguchi design compared working conditions, and 16 further cases examined work length, truck numbers and travel delay. Work length showed the largest change in the signal-to-noise score, at 5.60 dB. The full material requirement for 0.3 km was delivered at every tested delay. For 0.6 km, the delivered amount ranged from 85% to 100% of the requirement. For a uniform road section, 85% was enough to supply 0.510 km. The findings connect the daily target with the amount reaching the site. Truck numbers should be chosen together with work length and the capacity for loading, mixing and site work.

Keywords: Daily targets, Highway construction, Material delivery, Simulation, Truck Planning

1. INTRODUCTION

India's national highway network reached 146,572 km in March 2026, compared with 91,287 km in 2014. National highways with 4 or more lanes covered 45,516 km. By 31 March 2026, 22,590 km had been completed under Bharatmala (Press Information Bureau, 2026). Such a large road programme requires careful planning of materials, trucks and machines. Daily work can move smoothly when loading, mixing, transport and site work keep pace with one another.

Granular sub-base (GSB) and wet mix macadam (WMM) are lower layers of a road pavement. Figure 1 shows their position within the pavement structure.

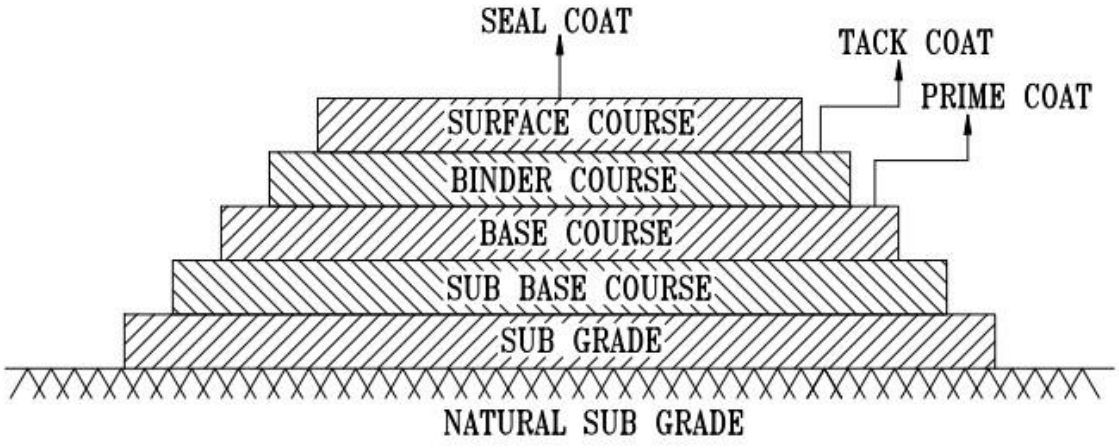


FIGURE 1. PAVEMENT LAYERS SHOWING THE SUB-BASE AND BASE COURSE

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Both require repeated deliveries of material. Trucks may wait at the plant for loading, while machines at the site wait for the next delivery. Vrijhoef and Koskela (2000) explained that a supply problem may begin in one part of the process and appear later in another. Cheng et al. (2010) examined how sharing information can improve coordination between construction organisations. Choudhari and Tindwani (2017) planned the sourcing, processing and delivery of road aggregates together.

Choosing a daily work length requires the same care. A longer stretch needs more material. More trucks can carry additional loads when the loading equipment, plant and site machines can handle them. This study compares the share of required material delivered and the road length that this material could supply. These two measures explain what each daily target means in practice.

2. REVIEW OF LITERATURE

Halpin (1977) described construction as a series of linked activities. AbouRizk and Halpin (1990) explained how simulation can allow for changes in repeated construction tasks. Martinez (2001) used activity diagrams to represent machines and materials working together. These methods allow loading, travel, waiting and unloading to be examined in one computer model.

For road materials, de Lima et al. (2013) used mathematical models to plan their movement during earthwork and paving. Jaśkowski et al. (2018) developed a model for choosing material supply routes. Alvanchi et al. (2021) used simulation and a search procedure for a 63.5 km road project with 6 material types and 28 sources. They reported about 1.5% savings in material transport and supply costs. These studies support planning the connected stages of material movement together.

Recent work has used site information to improve planning. Rashid and Louis (2022) used records of construction activities to update estimates of work output. Lee et al. (2023) prepared detailed road-earthwork schedules, dividing 3 broad activities into 36 in their case study. Zamani et al. (2023) used GPS and equipment-camera information to help decide how earthmoving equipment should be used. Zeng et al. (2024) linked material orders with the amount currently needed at the site.

Chen and Hammad (2023) reviewed 179 articles on construction supply chains. Zamani et al. (2024) examined 198 articles on construction simulation. This work supports comparing daily work lengths and truck numbers under changing travel conditions. The present study relates each GSB and WMM target to the material supplied and the length it could serve.

3. RESEARCH OBJECTIVE

To compare the percentage of required material delivered for sub-base and base-course work at different daily work lengths, truck numbers and travel delays between the mixing plant and the site.

4. RESEARCH METHODOLOGY

4.1 Field records and computer model

Bills of quantities, daily progress reports and records of material and machine use provided information from 62 highway projects. There were 60 observations for GSB and 60 for WMM. Material quantities were changed into amounts needed per kilometre. SPSS boxplots were used to check unusually high or low values. Figure 2 presents the steps from collecting records to building the model.

The Arena model followed materials from the quarry through storage and mixing to delivery at the site. Fresh supplies were ordered when stored material reached the set lower level. Quarry trucks brought material towards the mixing plant. Mix trucks carried the prepared material from the plant to the site. Figure 3 shows the movement of materials and supply information. Equal truck capacities were assumed, with 14 cubic metres per truck in the transport cases.

Jabri and Zayed (2017) also examined how construction machines work together. Sargent (2013) explained why a model should be checked for the task it is meant to support. Here, the model was used to compare daily material deliveries. Completion meant the amount delivered divided by the amount required, expressed as a percentage. Both amounts used the same measurement basis.

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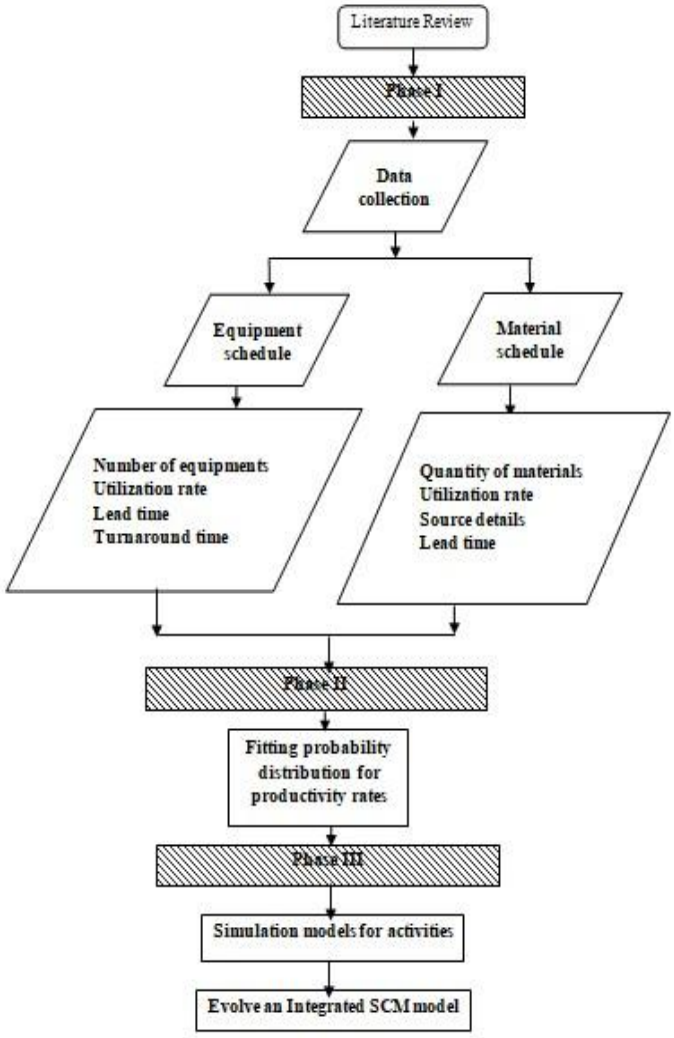


FIGURE 2. RESEARCH STEPS FOR MATERIAL AND EQUIPMENT PLANNING. SCM MEANS SUPPLY CHAIN MANAGEMENT.

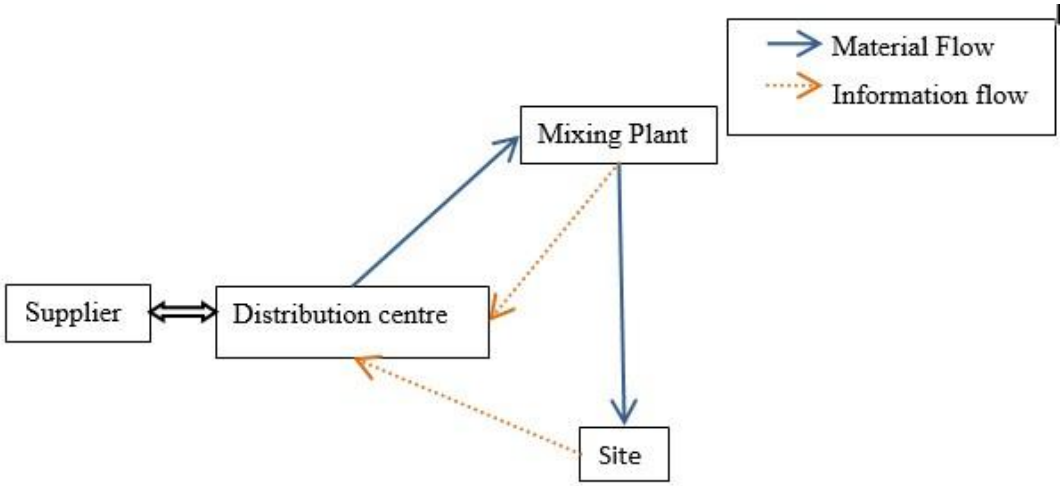


FIGURE 3. MATERIAL SUPPLY AND INFORMATION FLOW

4.2 Material needs and fitted curves

For a road section with the same width and thickness throughout, the compacted volume needed for 1 km was calculated from width b and thickness t, both measured in metres:

$V_k = 1000\ b\ t \quad (1)$

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In the worked example, the width was 13.36 m and thickness was 0.20 m. The recorded volume of 22,044 cubic metres for 8.25 km gave the same result:

$$V_k = \frac{22{,}044}{8.25} = 1000 \times 13.36 \times 0.20 = 2{,}672\ \mathrm{m}^3/\mathrm{km} \quad (2)$$

A 0.3 km target therefore needed 2,672 × 0.3 = 801.6 cubic metres of compacted material for this section. The daily length can thus be changed directly into the amount required.

The @RISK program fitted probability distributions, which describe how the recorded material amounts varied. Anderson–Darling and Kolmogorov–Smirnov tests were used to compare the fits. Fente et al. (2000) explained the use of suitable probability distributions in construction simulation. Figures 4 and 5 show the recorded values as bars and the fitted Weibull curves as lines. The GSB graph describes sub-base mix. The WMM graph describes its 40 mm aggregate component.

These curves represented different material needs in the model. The horizontal scale gives volume per kilometre. The vertical scale shows how closely the values are grouped. Each material was represented separately.

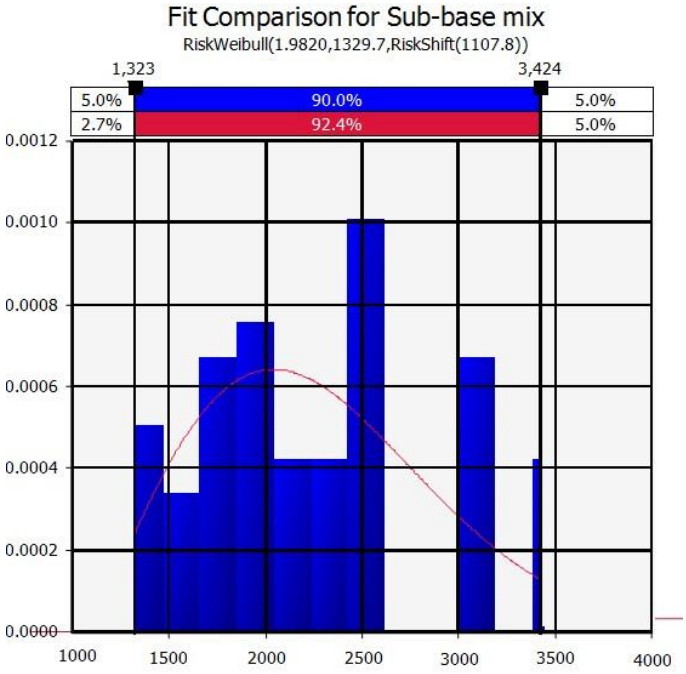


FIGURE 4. SUB-BASE MIX REQUIREMENTS AND FITTED WEIBULL CURVE. HORIZONTAL AXIS: M³/KM. VERTICAL AXIS: PROBABILITY DENSITY.

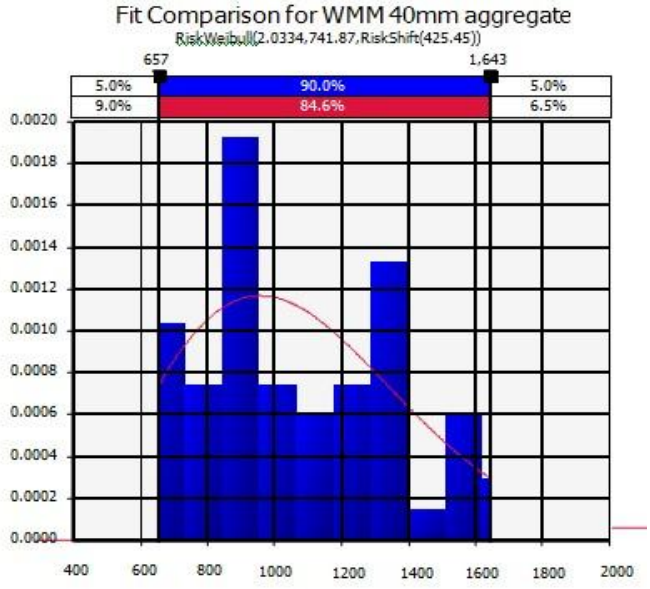


FIGURE 5. WMM 40 MM AGGREGATE REQUIREMENTS AND FITTED WEIBULL CURVE. HORIZONTAL AXIS: M³/KM. VERTICAL AXIS: PROBABILITY DENSITY.

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4.3 Tested conditions and calculations

The L16 Taguchi design compared 16 planned combinations. The tested values were 7–10 quarry trucks, 0.3–0.6 km of work, 3–6 mix trucks and 8–11 working hours per day. Each factor had 4 values. Travel delays of 5, 10, 15 and 20 minutes represented changes in transport conditions. Joshaghani et al. (2015) also used the Taguchi method to compare pavement mixture choices. Here, performance was measured by the percentage of required material delivered:

$$C = \frac{Q_{delivered}}{Q_{required}} \times 100 \quad (3)$$

C is the delivery percentage. Q delivered is the amount reaching the site, and Q required is the amount needed for the assigned work. The larger-the-better signal-to-noise ratio gave an S/N score for delivery completion:

$$\eta = -10 \log_{10} [\frac{1}{n} \sum_{i=1}^{n} \frac{1}{C_i^2}] \quad (4)$$

Each C value is a positive delivery percentage, and n is the number of values used. A higher score favours better and more consistent completion of the delivery target. For each factor, the mean score was calculated at each tested value. The difference between the highest and lowest mean scores was used to rank the factors:

$$\Delta_j = \max_l \eta_{jl} - \min_l \eta_{jl} \quad (5)$$

Here, j identifies the factor and l identifies its tested value. Another 16 cases compared 4 work lengths and 4 travel delays. The mix-truck number used in each case appears in Table 1. Each case represents its full combination of conditions.

5. RESULTS AND ANALYSIS

5.1 Truck numbers and working hours

For quarry trucks, the highest mean S/N score was 36.10 dB with 10 trucks. The scores for 7, 8 and 9 trucks were 35.53, 34.79 and 34.49 dB. Figure 6 shows these results. The difference between the highest and lowest scores was 1.61 dB.

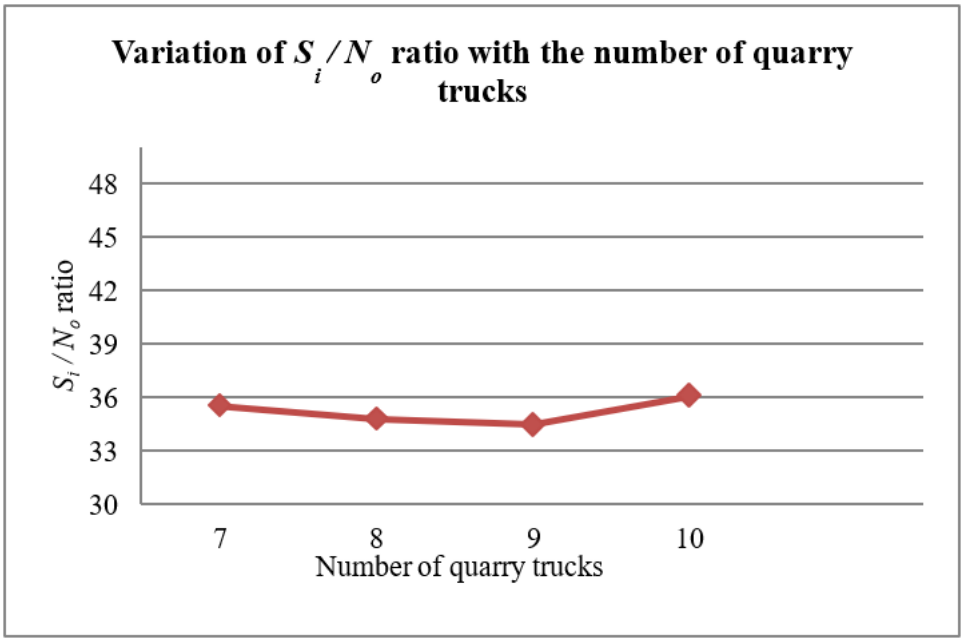


FIGURE 6. QUARRY TRUCK NUMBERS AND MEAN S/N SCORES IN DB

For mix trucks, the highest mean score was 35.82 dB with 3 trucks. The score with 4 trucks was close, at 35.70 dB. With 5 and 6 trucks, the scores were 34.79 and 34.60 dB. Figure 7 shows this pattern. The truck number therefore needs to suit the loading, mixing and site work.

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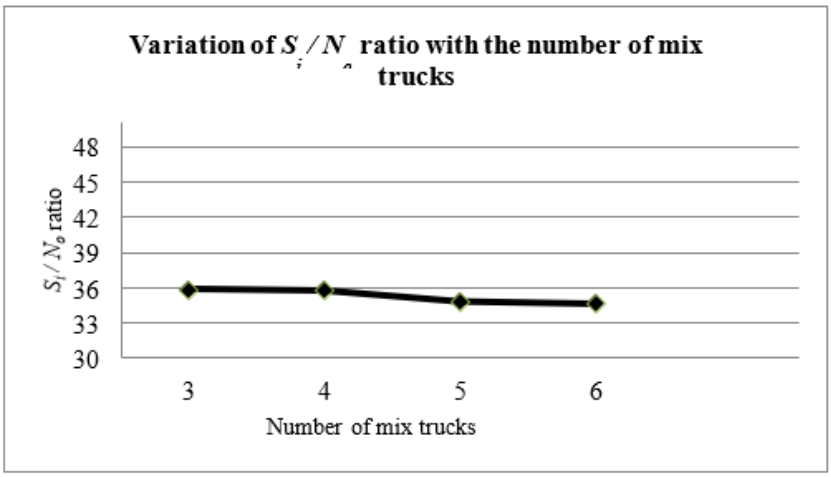


FIGURE 7. MIX TRUCK NUMBERS AND MEAN S/N SCORES IN DB

Figure 8 shows the highest working-hour score at 9 hours, with 36.50 dB. The scores at 8, 10 and 11 hours were 34.68, 34.65 and 35.07 dB. Together, these responses suggest 10 quarry trucks, 3 mix trucks and 9 working hours as a starting combination for planning.

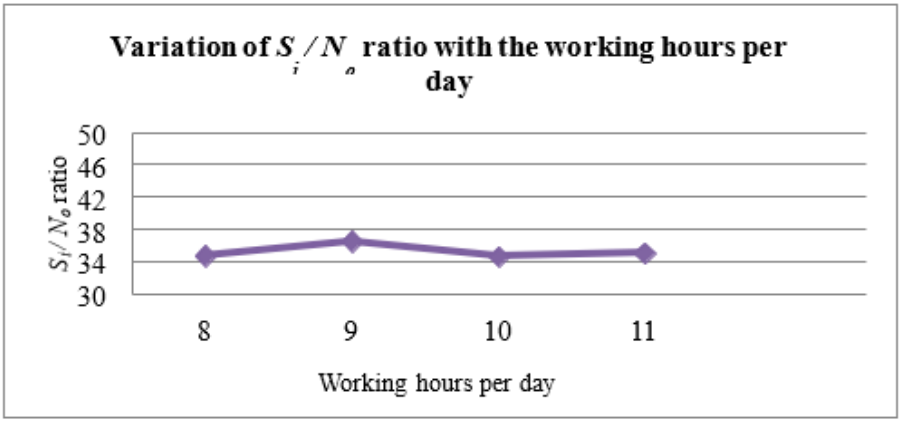


FIGURE 8. WORKING HOURS AND MEAN S/N SCORES IN DB

Work length had the largest score difference. Its mean fell from 37.77 dB for 0.3 km to 32.17 dB for 0.6 km, giving 37.77 − 32.17 = 5.60 dB. Working hours followed at 1.85 dB, quarry trucks at 1.61 dB, mix trucks at 1.22 dB and travel delay at 1.13 dB. This ranking suggests reviewing the daily work length when deliveries regularly fall short of the requirement.

5.2 Deliveries under different travel delays

The full material requirement was delivered in 10 of the 16 cases in Table 1. For 0.3 km, delivery reached 100% at all 4 delays. This required 2 mix trucks at 5 minutes and 3 at the longer delays. For 0.4 km, delivery remained at 100% through a 15-minute delay and reached 96% at 20 minutes.

Table 1. Material delivered and number of mix trucks

Delay (min)	0.3 km	0.4 km	0.5 km	0.6 km
5	100% (2)	100% (3)	100% (4)	100% (5)
10	100% (3)	100% (3)	100% (4)	98% (5)
15	100% (3)	100% (4)	90% (4)	88% (5)
20	100% (3)	96% (4)	93% (4)	85% (5)

Cells show the percentage delivered; numbers in brackets give the mix trucks. Columns give the daily work length. For 0.5 km, the delivery percentages were 100%, 100%, 90% and 93% at delays of 5, 10, 15 and 20 minutes. The matching percentages for 0.6 km were 100%, 98%, 88% and 85%. Average delivery completion across the 4 delays was 100% for 0.3 km and 92.75% for 0.6 km. The number of cases receiving the full amount fell from 4

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for 0.3 km to 3 for 0.4 km, 2 for 0.5 km and 1 for 0.6 km.
For a uniform road section, the road length that the delivered material could supply was calculated from the target length and delivery percentage:

$$L_{eq} = L_{assigned} \times \frac{C}{100} \quad (6)$$

At a 20-minute delay, 85% of the material for a 0.6 km target was delivered. This could supply 0.6 × 85/100 = 0.510 km. The fully supplied 0.3 km target could supply 0.300 km. At the same delay, the material for the 0.4 km and 0.5 km targets could supply 0.384 km and 0.465 km. These calculations connect each percentage with the amount requested. The 0.6 km case used 5 mix trucks, while the 0.3 km case used 3.

6. DISCUSSION

The full requirement for 0.3 km was met across the tested delays. The 0.6 km target received enough material for a longer stretch, even at 85% delivery. These cases used 5 mix trucks for 0.6 km and 2–3 for 0.3 km. A suitable daily target depends on the amount needed for the next road activity and the trucks available.
The balance between machines also matters. Lee and Kim (2025) examined how loading-machine and truck numbers affected waiting time, cost and duration in quarry work. Montenegro Defaz and Awuah-Offei (2026) found that excavator output depended on both loading time and the amount carried in each load. These findings support checking the full loading and transport process before adding trucks. Daily length, truck number, mixing output and site-handling capacity should be considered together.
Simple daily records can support these decisions. Abdelmegid et al. (2020) identified 14 barriers to the use of construction simulation. Clear inputs and results can make such models easier to use. A site team can record the target length, trucks sent, travel delay and material delivered. It can then compare the planned and delivered amounts and adjust the next daily target. Extra trucks can carry useful loads when materials are ready at the plant and the site can handle deliveries. González and Echaveguren (2012) used road-construction simulation to examine environmental performance. The same planning approach can later include fuel use and emissions.

7. CONCLUSION

Daily work length had the largest S/N score difference, at 5.60 dB. The 0.3 km target received its full material requirement at every tested delay. Material delivered for 0.6 km could serve 0.510–0.600 km. The response table suggested 10 quarry trucks, 3 mix trucks and 9 working hours as a starting combination. Managers should match truck numbers with the daily target, material needs and capacity of the other machines.

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