A First DOE: Liquid Ratio and Filler Content

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Abstract. Use a two-factor screen to examine liquid ratio and filler content together. This note presents a factorial comparison and explains main effects, interaction and follow-up checks. The example is a screening design and does not establish an optimized formulation.

Keywords: DOE; factorial design; interaction; liquid ratio; filler content

1. Define factors that can vary independently

For an illustrative cement screen, factor A is liquid/total powder at 0.30 or 0.40 mL/g; factor B is filler replacement at 0 or 10 wt% of total powder. Fix the powder lot, filler size, liquid chemistry, mixing and test age. First confirm that all four combinations can be prepared and measured.

The table gives a two-level, two-factor design in standard order. Randomize actual preparation order; do not treat the table order as the run sequence. A full factorial covers every combination [1]. Because filler replaces cement, also calculate liquid/reactive cement to help interpret the effects.

Choose one primary response before the trial, such as a defined extrusion-force metric, plus essential constraints such as setting and composition retention. Use two independent mixes at each corner as an initial eight-mix screen; additional replication depends on observed variation and the required decision confidence.

2. Read effects before chasing an optimum

2.1 Calculate contrasts. Let the four cell means be y_{--}, y_{+-}, y_{-+} and y_{++}. The A effect is $(y_{+-} + y_{++} - y_{--} - y_{-+})/2$. The AB interaction effect is $(y_{--} + y_{++} - y_{+-} - y_{-+})/2$. Compare these effects with variability between independent mixes, not just repeated readings of one mix.

2.2 Work through a hypothetical response. Suppose force means in table order are 120, 80, 180 and 90 N. The A effect is −65 N. The AB effect is −25 N: raising liquid reduces force more strongly at the higher filler level. These are invented arithmetic values, not experimental results or recommended forces.

2.3 Add a confirmation stage. Prepare fresh mixes at the candidate condition and, if useful, independent center points at A = 0.35 mL/g and B = 5 wt%. A center response unlike the corner-based prediction signals curvature or other model limitations. Inspect constraints even when the primary response improves.

3. Development decision

Use the first screen to choose the next local experiment, not to declare a universally optimal recipe. If interaction is substantial, report a joint operating region for liquid and filler rather than independent allowable ranges.

Table 1. Development comparison and interpretation controls.

Setting (A, B)	Liquid for 10 g total powder	Cement / filler
Low, low (−, −)	3.00 mL	10.0 / 0 g
High, low (+, −)	4.00 mL	10.0 / 0 g
Low, high (−, +)	3.00 mL	9.0 / 1.0 g
High, high (+, +)	4.00 mL	9.0 / 1.0 g

Scope. Levels, replication and force values are illustrative. A mixture with additional constrained components may require a mixture or combined design.

References

1. NIST/SEMATECH. e-Handbook of statistical methods [Internet]. 5.3.3.3.1. Two-level full factorial designs [cited 2026 Sep 28]. Available from: https://www.itl.nist.gov/div898/handbook/pri/section3/pri3331.htm

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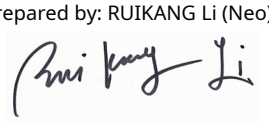

Reviewed by: Alex | Technical content: Approved

Review date: