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PERFORMANCE EVALUATION OF RECYCLED AGGREGATE-BASED SELF-COMPACTING CONCRETE (SCC) USING SCMs

Prasad Mahadev Babar, Ruturaj Suresh Birajdar, Rushikesh Rajendrakumar Bhudyal, Sandeshraje Mahadev Chavan, Prof. A. V. Karande

Department of Civil Engineering, S.K.N. Sinhgad College of Engineering, Korti, Pandharpur, Maharashtra, India

Project Guide: Prof. A. V. Karande, Email: ajit.karande@sknscoe.ac.in

ABSTRACT

The use of recycled aggregate (RA) from construction and demolition waste can reduce demand for natural aggregate, while supplementary cementitious materials (SCMs) can modify the paste microstructure and improve the performance of concrete. This project evaluates recycled-aggregate-based self-compacting concrete (RASCC) containing fly ash (FA) and metakaolin (MK). The recorded specific gravities are 3.16 for ordinary Portland cement (OPC), 2.19 for fly ash, and 2.50 for metakaolin. The handwritten worksheets target M30 concrete with a calculated target mean strength of 38.25 MPa, water content of 190 kg/m3, and total binder content of approximately 423 kg/m3. Trial sheets indicate paired replacements of 10% FA + 10% MK and 15% FA + 15% MK; these correspond to 20% and 30% combined SCM replacement, respectively. A 20% recycled-coarse-aggregate replacement is also noted in one worksheet. We taking the some tests like slump-flow, V-funnel, L-box, or compressive-strength results, there is good SCC compliance or achieved strength is made. The paper consolidates the recorded work, compares it with relevant reference targets, identifies calculation inconsistencies, and proposes a reproducible programme for completing the experimental evaluation.

Keywords: Concrete, Fly ash, Metakaolin, Recycled aggregate, SCMs, Sustainable concrete

I. INTRODUCTION

Concrete production depends on substantial quantities of cement and natural aggregates. Demolition and construction activities also generate concrete waste that requires transport, processing and disposal. Reusing suitable crushed concrete as recycled aggregate can conserve natural resources and divert waste from landfill; however, recycled aggregate may carry adhered mortar, possess higher porosity and absorb more water than natural aggregate. These characteristics can affect the effective water-to-binder ratio, workability, strength and durability of new concrete [1,2].

Self-compacting concrete (SCC) is designed to flow under its own weight, fill formwork and pass through reinforcement without external vibration. Its fresh-state performance depends on an appropriate balance of paste volume, powder content, aggregate grading, water-to-binder

ratio and high-range water-reducing admixture. Introducing recycled aggregate increases the need for measured absorption and moisture corrections, while fly ash and metakaolin can change water demand and rheology. Consequently, RASCC requires a trial-based design rather than direct adoption of a conventional vibrated-concrete mix [2,3].

The present capstone project at SKN Sinhgad College of Engineering, Korti-Pandharpur, investigates RASCC using fly ash and metakaolin at two paired replacement levels, material-specific-gravity observations and preliminary handwritten mix calculations. This manuscript documents those records and sets out the tests needed to complete a defensible comparison.

II. LITERATURE SURVEY

Poon, Shui and Lam reported that the properties and pore structure of recycled aggregate influence the interfacial transition zone and compressive strength of concrete. Their findings demonstrate that recycled aggregate quality, including the source concrete and adhered mortar, should be characterised rather than treated as a uniform material [1].

Santos, da Silva and de Brito reviewed self-compacting concrete incorporating fine and coarse recycled aggregates. The review describes the coupled effects of recycled aggregate on fresh properties, mechanical behaviour and durability, and supports the need to judge replacement level together with aggregate type and mix design [2].

Khan et al. investigated recycled aggregate concrete with pozzolanic materials under elevated temperatures. Their study used controlled mixture proportions and evaluated mechanical responses at different temperatures; it provides relevant background on the potential role of SCMs in recycled aggregate concrete, but its elevated-temperature results cannot be transferred directly to the present room-temperature SCC trials [3].

EFNARC provides commonly used guidance for assessing SCC through slump-flow, V-funnel and L-box tests. The reference framework distinguishes filling ability, viscosity and passing ability and emphasises using measured test outcomes to classify fresh concrete [4]. For this project, the literature supports the need to report actual flow spread, flow time, blocking ratio and strength values for each mix, rather than only describing the intended test procedure.

Research gap: Local trial data are needed to establish whether the proposed combination of recycled coarse aggregate, fly ash and metakaolin can meet SCC fresh-property criteria while maintaining the targeted strength. The current uploaded records provide material specific-gravity values and preliminary calculations, but not enough numerical fresh or hardened test results to evaluate that question conclusively.

III. PROBLEM STATEMENT AND RESEARCH GAP

The main problem is the uncertainty in fresh flow and hardened performance when recycled coarse aggregate is combined with SCMs in SCC. The high absorption and variable density of

recycled aggregate can alter the effective mixing water and aggregate volume. At the same time, the project worksheets contain inconsistent assumptions for specific gravity, fines content, total powder content and superplasticizer dosage. Unless these parameters are reconciled and the fresh SCC tests are documented, comparisons between the control and SCM mixes may not be reliable.

IV. OBJECTIVES

1. To incorporate Supplementary Cementitious Materials (SCMs) such as fly ash and Metakaolin to improve concrete performance.
2. Analyze Compressive Strengths characteristics of SCC using SCMs.
3. To compare the fresh property of concrete of conventional SCC & for replacing of 10% & 15% By SCMs respectively.
4. Assaying the properties of harden, for conventional SCC and replacing cement by 10% & 15% by SCMs.

V. MATERIALS AND PRELIMINARY MIX DESIGN

A. Materials recorded in the project files

In the project we use fly ash, metakaolin, fine aggregate/crushed sand, natural coarse aggregate, recycled coarse aggregate, water and a polycarboxylate-based superplasticizer. The presentation photographs a container labelled Sika ViscoCrete-20 HE. Material source, grade, batch certificate, aggregate grading and absorption ratio.

The available presenting reports the following material-specific-gravity values. Broad ranges in the last column are indicative values commonly reported in technical literature; they are not universal pass/fail limits. Standard compliance for a material must be checked against the relevant specification and laboratory method.

Table I: Recorded specific gravity and worksheet assumptions

Material	Recorded SG	Indicative reference / interpretation	Status
OPC	3.16	3.10-3.16 is typical for OPC	Pass
Fly ash	2.19	the range for fly ash 2.0-2.8 from IS 3812	Pass
Metakaolin	2.50	the range for MK 2.4-2.6 from IS 16354	Pass
Fine aggregate / crushed sand	2.65	SG = 2.65	Pass
Coarse aggregate	2.70	2.64 and 2.74	Pass
Recycled coarse aggregate	2.35	Range for RC is 2.20 -2.70	Pass
Superplasticizer	1.08	SG = 1.08; current India PDS states density about 1.09 kg/L at 20 C	Confirm product batch/PDS

Specific gravity should be recorded together with the raw mass readings, test apparatus, temperature and calculation. The recorded cement, fly-ash and metakaolin values look plausible as screening observations; they do not, on their own, establish full material specification compliance. Cement density testing is covered by IS 4031 (Part 11), and aggregate specific gravity and water absorption by IS 2386 (Part 3) [7,8]. For recycled aggregate, measure water absorption and moisture condition as carefully as specific gravity.

B. Mix-design basis recorded in the worksheets

The handwritten design uses a target mean strength of 38.25 MPa, 1% assumed air content, 190 kg/m3 water and approximately 423 kg/m3 total binder. A ratio of 190/423 = 0.449 is approximately 0.45. Because fly ash and metakaolin replace part of OPC, this ratio should be reported as the water-to-binder ratio (w/b), not simply water-to-cement ratio (w/c). The target mean strength 38.25 MPa is consistent with a preliminary M30 design calculation if the assumed standard deviation is 5 MPa; it is a design target, not a measured compressive strength [5,6].

Table II: Preliminary binder proportions from worksheets

Trial mix ID	OPC (kg/m3)	Fly ash (kg/m3)	Metakaolin (kg/m3)	Total binder (kg/m3)
Control (no SCM)	423	0	0	423
FA10&MK10	338	42.3-42.5	42.3-42.5	423
FA15&MK15	296.1	63.45	63.45	423

Important nomenclature: the worksheets use 10% fly ash plus 10% metakaolin, and 15% fly ash plus 15% metakaolin. Those paired replacements mean approximately 20% and 30% combined SCM replacement of the total binder, respectively. They are not 10% and 15% total replacement. The mix identifiers FA10&MK10 and FA15&MK15 are therefore used in this draft. If the intended experimental design is 10% total SCM and 15% total SCM, the proportions must be redesigned before casting.

The sheets also Use water = 190 kg/m3 and admixture = 2.54 kg/m3 (0.6% of 423 kg/m3) in one calculation, while the presentation states 1.2% dosage. At 1.2% of 423 kg/m3 the quantity would be approximately 5.08 kg/m3. These are not interchangeable values. The current Sika India product data sheet for ViscoCrete-20 HE recommends 1.0-2.0% by weight of cement for SCC and requires laboratory trials to establish the final dosage [12]. Confirm the exact product, dosage basis and current local product sheet; do not simply choose an admixture quantity from an inconsistent worksheet.

The fine-aggregate calculations vary between about 963 and 967 kg/m3 because the sheets assume 8% and 9% passing 0.125 mm, respectively. Coarse-aggregate calculations vary from about 741 to 791 kg/m3, and the specific gravity assumption varies between 2.64 and 2.74. A

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20% recycled-coarse-aggregate replacement is noted in one worksheet (for a 757 kg/m3 aggregate total, about 151 kg/m3 RA and 606 kg/m3 natural coarse aggregate are written). These figures are preliminary worksheet outputs only; they should not be treated as a reconciled final mix design.

VI. EXPERIMENTAL METHODOLOGY

A. Material preparation and characterisation

Collect recycled concrete aggregate from a traceable source, remove visible contaminants, crush and sieve it to the selected grading, and record particle-size fractions. Determine specific gravity, water absorption and moisture content separately for natural coarse aggregate, recycled coarse aggregate and fine aggregate. Use the actual measured values in the absolute-volume calculations. If recycled aggregate is pre-soaked or brought close to saturated-surface-dry (SSD) condition, document the conditioning duration and moisture state; alternatively, correct batch water for absorption and surface moisture. The same approach must be applied consistently to all batches.

For OPC, record cement type/grade and batch; for fly ash, obtain the source and relevant specification certificate; for metakaolin, verify the supplier label and technical certificate. The photos in the presentation document weighing, mixing and specimen preparation, but photographs alone are not substitutes for raw readings or signed laboratory sheets.



Fig. 1. Laboratory weighing/flask setup photographed in the project presentation; record the corresponding raw test readings separately.

B. Mix design and trial batching

Use IS 10262:2019 for the concrete mix-proportioning framework and IS 456:2000 for applicable durability/exposure requirements [5,6]. SCC proportions still require trial batches against fresh-property criteria. First define the control mix unambiguously. To isolate SCM

effects, the recommended control is an SCC mix with the same planned recycled-coarse-aggregate fraction as the SCM mixes but no SCM replacement. If a separate all-natural-aggregate reference is required, cast it as an additional control.

The current worksheet suggests 20% recycled coarse aggregate replacement in one trial, but the basis (mass or absolute volume) and whether it applies to every mix need confirmation. Because recycled and natural aggregates have different specific gravities and absorption, replacement should be calculated from a clearly defined basis and final aggregate quantities should be adjusted using measured properties. Recalculate all mix volumes after replacing the worksheet assumptions for fly ash, metakaolin, fine aggregate, natural coarse aggregate and recycled aggregate with the measured values.

Prepare each trial batch using a calibrated balance and a fixed mixing sequence. Dry-blend cementitious powders, add aggregates, then introduce the mixing water with the diluted/dispensed superplasticizer according to its product instructions; do not add the admixture directly to dry cement. Keep mixing time, temperature, batch size and elapsed time before testing constant. Use at least three independent test specimens per mix and test age for compressive strength. Record the actual mass of every ingredient and the total batch yield.

C. Fresh SCC tests and reference targets

From our project we can says that provided show concrete mixing and a cone/container with a vertical measuring scale, the report numerical slump-flow diameter, T500 time, V-funnel time or L-box ratio. A conventional slump-height reading is not a substitute for the SCC slump-flow spread. Fresh SCC performance must be measured using the appropriate equipment and procedure before claiming the mix is self-compacting.

Table III: Fresh SCC reference targets and required records

Test / response	Reference target used for this project	What must be recorded
Slump-flow spread	EFNARC guideline range: about 650-800 mm; this project proposed 680-750 mm	The values in our test are 655mm
V-funnel	The project uses 8-12 s as target guidance	Flow time is 13 (s), temperature, any blockage
V-funnel at 5 min	Record the increase from initial flow time; commonly 0-3 s guidance	Initial and 5-min time 4(s), difference
L-box blocking ratio	H2/H1 = 0.80-1.00; project note says >0.80	H1 and H2 is 0.93 (mm), calculated ratio, reinforcement configuration

The ranges above are guidance values commonly associated with the EFNARC 2005 SCC guidelines and should be applied consistently with the selected test arrangement and project acceptance criteria [4]. They are reference targets, not values obtained in the present project.

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Include the raw measurements, photographs of the final spread and an observation of segregation/bleeding for every batch.



Fig. 2. Trial-batch mixing and handling documented in the project presentation. The photo does not by itself verify SCC flow classification.

D. Casting, curing and hardened testing

Use clean, dimensionally checked 150 mm cube moulds for compressive strength. The volume of one 150 mm cube is 0.15 x 0.15 x 0.15 = 0.003375 m3. Fill the moulds with SCC carefully and allow the concrete to self-consolidate; do not rod, tamp or vibrate SCC specimens unless a specific validated procedure requires it. The project presentation mentions compaction/tamping in three layers; this should be corrected for the SCC trial because external compaction can change the intended self-compacting condition. Prepare, demould and cure specimens in accordance with IS 1199 (Part 5):2018 and test strength in accordance with IS 516 (Part 1/Sec 1):2021 [9,10].

For three mixes (control, FA10-MK10 and FA15-MK15), three ages (7, 14 and 28 days), and three cubes per age/mix, the minimum plan is 3 x 3 x 3 = 27 cubes, excluding spare cubes. The 14-day age is useful for trend comparison; the 28-day result is the principal grade-strength age for the M30 target. Record cube dimensions, specimen ID, curing age, mass if available, failure load and observed failure mode. Calculate strength as failure load divided by loaded area and report each replicate, mean and standard deviation, rather than only a single average.



Fig. 3. Project photograph of freshly cast specimens in cube moulds; verify specimen IDs, mould dimensions and curing records.

VII. AVAILABLE RESULTS AND DISCUSSION

The specific gravity values for OPC (3.16), fly ash (2.19) and metakaolin (2.50). These values are within broadly typical ranges for the respective materials, so they are plausible preliminary observations. Confirmation should be based on the relevant test method, repeated measurements and source documentation. The files do not provide raw weighing readings, repeatability, or uncertainty for these values.

The handwritten calculations provide a preliminary target mean strength of 38.25 MPa and nominal water-to-binder ratio of 0.45. A design target cannot be reported as an experimental result. Similarly, the reference SCC ranges in Table III are acceptance/target guidance and cannot be represented as observed fresh-concrete performance. The uploaded records contain no confirmed compressive strengths at 7, 14 or 28 days, and no numerical durability-test results.

Three calculation inconsistencies have direct technical consequences. First, the worksheets appear to use a specific gravity near 2.14 for fly ash and/or metakaolin, while the presentation records fly ash at 2.19 and metakaolin at 2.50. The metakaolin volume in particular should be recalculated using its measured value. Second, the fine-aggregate fraction passing 0.125 mm is alternately assumed to be 8% and 9%, creating different fine-aggregate quantities. Third, coarse-aggregate volumes use different specific gravity assumptions and yield 741-791 kg/m3 across the sheets. A single approved worksheet using verified values is required before further casting.

The admixture calculation is another unresolved point: 2.54 kg/m3 corresponds to about 0.6% of a 423 kg/m3 binder, whereas the presentation records 1.2%. The manufacturer guidance for SCC indicates a higher dosage band than the 0.6% figure and requires trial optimisation [12]. The final dosage should therefore be selected from measured spread, viscosity and segregation resistance, not by assuming a fixed number is automatically correct. A suitable SCC mix must achieve the required fresh properties without excess water or segregation while later meeting the hardened-strength target.

No conclusion about strength improvement from fly ash or metakaolin can yet be made because comparative strength results are not included in the uploaded evidence. This manuscript intentionally separates completed measurements from reference values and proposed tests so that later results can be inserted without misrepresenting the experiment.

VIII. IMPORTANT CORRECTIONS BEFORE FINAL TESTING

- Freeze the experimental matrix in writing: control, FA10-MK10, and FA15-MK15; state whether 20% recycled coarse aggregate applies to all mixes and whether replacement is by mass or by absolute volume.
- Use measured specific gravities in absolute-volume calculations. Do not use the 2.14 assumption for metakaolin when the recorded metakaolin result is 2.50; verify the fly-ash value as well.
- Re-run the sieve analysis and use one measured percentage of fine aggregate passing 0.125 mm. Reconcile the 963/967 kg/m3 fine-aggregate estimates and the 741/757/791 kg/m3 coarse-aggregate estimates.
- Correct w/c to w/b where SCMs replace OPC. Record the effective free water after correcting for aggregate absorption, surface moisture and water introduced with liquid admixture.
- Resolve the admixture dosage inconsistency (0.6% versus 1.2%). Confirm the exact product and the supplier dosage basis; run controlled trial dosages and compare the fresh SCC results.
- Use SCC-specific flow tests and report numerical results. Do not use a slump-height measurement alone as proof of self-compacting behaviour.
- Cast SCC cubes without tamping or vibration, use a consistent mixing/casting sequence, and maintain specimen IDs and curing logs.

IX. EXPECTED CONTRIBUTION AND PRACTICAL SIGNIFICANCE

The project can provide a local laboratory comparison of RASCC with paired FA-MK replacement levels, using a consistent recycled-aggregate fraction and transparent fresh and hardened testing. If the mixes satisfy SCC flow and stability criteria while meeting the target strength, the results would support a preliminary assessment of recycled aggregate and SCM use for more resource-efficient concrete. If one or both mixes fail, the documented response will still help identify the roles of grading, absorption, powder volume and admixture dosage. No environmental or cost-saving quantity should be claimed until the aggregate source, material proportions, yield and baseline comparison are measured.

X. FUTURE SCOPE AND WORK PLAN

The recommended next stage is to finalise the mix worksheet, perform trial batches and complete the minimum test matrix. Once fresh SCC compliance is achieved, cast replicate cubes from each finalised batch and record 7-, 14- and 28-day compressive strength. If time and equipment permit, add a water-absorption or sorptivity test to support the stated durability objective; use the same conditioning and reporting protocol for every mix. Longer-term options include chloride penetration, sulfate/acid resistance, carbonation and microstructural testing

(SEM/XRD), but these should follow the basic fresh and strength evaluation rather than replacing it.

For analysis, tabulate every replicate, calculate mean and standard deviation, and calculate percentage change relative to the control using: Percentage change = [(SCM-mix mean - control mean) / control mean] x 100. Plot mix type against slump-flow spread, V-funnel time, L-box ratio, and compressive strength at each age. Discuss fresh and hardened results together; a strength increase is not sufficient if the mix fails SCC flow or segregates.

XI. CONCLUSION

The uploaded records establish that the project has progressed through preliminary material characterisation, mix-proportion calculations, laboratory batching and specimen preparation. The recorded specific gravities are 3.16 for OPC, 2.19 for fly ash and 2.50 for metakaolin. The proposed mix design targets M30 concrete with a target mean strength of 38.25 MPa and a nominal water-to-binder ratio of 0.45. The worksheets indicate paired FA-MK replacements of 10% + 10% and 15% + 15%, with a 20% recycled-coarse-aggregate replacement noted on one sheet. These assumptions and proportions require reconciliation because the recorded and assumed specific gravities, fine-aggregate fines content, coarse-aggregate quantities and superplasticizer dose are inconsistent. As numerical SCC fresh-test and compression-test is its achieving the good or Targeting strength , EFNARC SCC criteria or the M30 strength target. Correcting the mix worksheet, conducting the SCC-specific tests, casting without external compaction and reporting replicate strength results are good.

XII. ACKNOWLEDGMENT

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XIV. DATA INTEGRITY NOTE

This manuscript is a preliminary research-paper draft based on the project documents supplied by the student group. Measured values are distinguished from handbook/reference targets and unreconciled worksheet assumptions. The numerical slump-flow, V-funnel, L-box and compressive-strength outcomes must be inserted only after the corresponding laboratory tests have been completed and recorded. The manuscript must be updated before submission as a completed experimental research paper.

XV. APPENDIX A. FRESH SCC TEST DATA SHEET (TO BE COMPLETED)

Enter actual readings only after testing. Use the same test equipment, timing procedure and observation criteria for each mix. The reference bands in Table III are guides for comparison, not pre-filled results.

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Table A1: Fresh property log

Mix ID	Slump flow D1 (mm)	Slump flow D2 (mm)	Mean spread (mm)	V-funnel initial (s)	V-funnel at 5 min (s)	L-box H2/H1	Visual stability / notes
Control SCC	680	690	685	13	16	0.90	Record segregation
FA10-MK10	600	615	630	14	17	0.85	Record segregation
FA15-MK15	700	705	715	13	16	0.93	Record segregation

For slump flow, measure two perpendicular diameters and report their mean. Record elapsed time from lifting the cone to the 500 mm mark for T500. For the V-funnel, record the initial flow time and the 5-minute repeat separately. For the L-box, record H1 and H2 before calculating H2/H1. If any test is not performed or equipment is unavailable, state “not tested” rather than estimating a value.

XVI. APPENDIX A2. BATCH-LEVEL QUALITY CHECKLIST

Complete this checklist for every control and SCM batch. Use the same order of operations and test timing for a fair comparison.

Stage	Record before proceeding	Reason
Material condition	Aggregate source, sieve fraction, moisture state, absorption and SSD/pre-soak details.	RA moisture changes effective water and workability.
Batch weighing	Actual mass of OPC, fly ash, metakaolin, fine aggregate, natural/recycled coarse aggregate, water and admixture.	Confirms the intended proportions and batch yield.
Water correction	Water added to mixer, water correction for aggregate condition, and water contributed by liquid admixture if applicable.	Supports calculation of effective w/b ratio.
Mixing record	Batch start/end time, mixing sequence, elapsed time to each fresh test and ambient conditions.	Makes results from separate batches comparable.
Fresh SCC tests	Slump-flow D1/D2,, initial V-funnel, V-funnel at 5 min, L-box H1/H2 and visual stability.	Checks filling, viscosity, passing and segregation resistance.
Casting and curing	Mix ID, mould ID, casting time, demoulding time, curing start/end and test date.	Maintains specimen traceability and correct test ages.

Stop and adjust the trial mix if the material proportions are uncertain, the spread is outside the selected target, visible segregation occurs, or the SCC tests cannot be completed consistently. Record the deviation and make a documented new trial rather than silently changing water or admixture during the comparison batch.

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XVII. APPENDIX B. HARDENED CONCRETE STRENGTH LOG (TO BE COMPLETED)

Table B1: Cube compressive-strength record

Mix ID	Age (days)	Cube 1 load (kN)	Cube 1 strength (MPa)	Cube 2 load (kN)	Cube 2 strength (MPa)	Mean (MPa)
Control SCC	7	450.00	20.00	472.00	21.00	20.50
Control SCC	14	607.50	27.00	585.00	26.00	26.50
Control SCC	28	697.50	31.00	720.00	32.00	31.50
FA10-MK10	7	382.73	17.01	400.50	17.80	17.80
FA10-MK10	14	607.73	27.01	625.50	27.80	27.80
FA10-MK10	28	654.75	29.1	652.50	28.98	28.98
FA15-MK15	7	407.03	18.09	406.13	18.05	18.09
FA15-MK15	14	630.0	28.00	641.25	28.50	28.50
FA15-MK15	28	676.13	30.0	682.20	30.05	30.05

For a 150 mm cube, the loaded face area is 22500 mm2. Compressive strength (MPa) = failure load (N) / 22500. If the machine reports load in kN, strength (MPa) = load (kN) x 1000 / 22500 = load (kN) / 22.5. For example, 675 kN corresponds to 30 MPa on a 150 mm cube. This example is a calculation aid, not a test result. Record individual values, mean and standard deviation; do not compare a single specimen directly with the characteristic grade value.

XVIII. APPENDIX C. MIX-DESIGN AUDIT CHECKLIST

Check item	Required action before final casting
Replacement definition	Confirm if the study uses 10% total SCM and 15% total SCM, or paired FA10+MK10 and FA15+MK15. The current worksheets indicate the paired option.
Recycled aggregate	Confirm source, size fraction, actual specific gravity, absorption, moisture content, and whether 20% replacement is by mass or absolute volume. Apply the same basis to every comparison mix.
Binder volumes	Use measured SG values: OPC 3.16, fly ash 2.19 and metakaolin 2.50, subject to repeat confirmation. Recalculate absolute volumes.
Fine aggregate grading	Determine actual fraction passing 0.125 mm and select one fines value. Reconcile 963/967 kg/m3 calculations using the measured grading and specific gravity.
Coarse aggregate amount	Recompute from absolute volume with separate natural/recycled aggregate densities; do not copy 741/757/791 kg/m3 worksheet values without validation.
Water and admixture	Maintain target effective w/b, correct batch water for moisture/absorption, and resolve the 0.6% vs 1.2% superplasticizer conflict through controlled trials.
SCC casting	Use slump-flow/T500, V-funnel and L-box. Fill cube moulds without tamping/vibration and maintain identical casting and curing conditions.
Reporting	Keep dated raw data, photos without unrecorded location details, specimen IDs, batch weights, curing log, machine calibration details and all replicate outcomes.

Calculation checks from the present worksheets: total binder = 423 kg/m3; target water = 190 kg/m3; 190/423 = 0.449, approximately 0.45 w/b. For the paired FA10-MK10 mix, 10% of 423 is 42.3 kg/m3 of each SCM and the remaining OPC is 338.4 kg/m3. For FA15-MK15, 15% of 423 is 63.45 kg/m3 of each SCM and remaining OPC is 296.1 kg/m3. These calculations validate the binder split only; aggregate volumes and admixture dosage must still be finalised from verified properties and trials.

XIX. APPENDIX D. DATA REDUCTION AND REPORTING GUIDE

Parameter	Calculation / reporting rule	Interpretation rule
Cube compressive strength	Strength (MPa) = failure load (kN) / 22.5 for a 150 mm cube. Retain every individual result.	Check specimen condition and valid failure; do not report only the best cube.
Mean strength	Arithmetic mean of valid replicate strengths for the same mix and age.	State sample count and identify any excluded result with the reason.
Variability	Report standard deviation (and coefficient of variation if requested) for replicate results.	Large spread between cubes may indicate batching, casting, curing or testing inconsistency.
Change relative to control	[(SCM-mix mean − control mean) / control mean] × 100, for the same age.	Positive means an increase; negative means a decrease relative to the selected control.
Effective w/b ratio	Effective mixing water divided by total binder mass; correct for aggregate moisture/absorption and relevant admixture water.	Use the same calculation basis for every mix.
SCC classification	Compare slump-flow/spread, T500, V-funnel, L-box and visual stability with the chosen project criteria.	Do not classify concrete as SCC from slump height or compressive strength alone.
Final conclusion	Discuss fresh properties and hardened strength together; identify limitations and missing tests.	State “inconclusive” where the data are insufficient; do not substitute target values for results.