DOI - 10.68648/ijte-q-2026-49-03-005

Similitude Framework for Scale Modelling of Dry-Stacked Interlocking Compressed Earth Block Walls

Vishal Kumar Chaudhary
Assistant Professor
Dept. of Civil Engineering
Government Engineering College Khagaria
Khagaria
✉ vishal@geckhagaria.org.in

Sneha Kumari
Assistant Professor
Dept. of Civil Engineering
Gaya College of Engineering
Gaya
✉ sneha21.dstte@bihar.gov.in

Sumit Suman
Assistant Professor
Dept. of Civil Engineering
Government Engineering College Khagaria
Khagaria
✉ suman.sumit@geckhagaria.org.in

ABSTRACT

Interlocking compressed earth blocks (ICEBs) are machine-pressed soil blocks that stack together like toy bricks, without mortar. They offer a low-cost, low-carbon way to build houses in earthquake-prone regions. Laboratory testing of ICEB walls remains rare because full-size tests need large and costly equipment. Testing small models instead would solve this problem, but only if clear rules exist to make the small model behave like the real wall. Such rules, called similitude rules, do not yet exist for dry-stacked interlocking earthen walls, because these walls act through friction and interlocking between blocks rather than as one solid material. This paper derives the missing rules using dimensional analysis. Three ratios must be matched between model and prototype: the friction between block faces, the ratio of key strength to friction resistance, and the ratio of vertical load to block strength. The paper shows how to correct the reduced self-weight of a small model with added weights, how to correct for size effects, and how to press model blocks in 3D-printed moulds. A quarter-scale worked example based on published test data requires only a 37 kg added weight and one sixteenth of the lateral testing force.

KEYWORDS *: Compressed earth block, Dimensional analysis, Dry-stack masonry, Scale modelling, Similitude.*

NOTATIONS

λ: scale factor (model size divided by prototype size)
L: block length
H: wall height
f_b: block compressive strength
f'm: masonry (prism) strength
E: modulus of elasticity
ρ: density
g: gravitational acceleration
μ: friction coefficient between bed faces
τ_k: key shear strength
A_k, A_c: key area and block contact area
σ_v: vertical stress at a joint
σ_n: normal stress at the joint considered
σ_r: roof (service) surcharge
$\Delta\sigma$: added compensating surcharge
$\hat{g}$: joint gap
F: lateral force
δ: displacement
a: acceleration
t: time (dynamic loading)
t_w: wall thickness

κ_f, κ_k: measured size-effect corrections on block and key strength

Π_1, Π_2, Π_3: the three governing dimensionless ratios; subscripts m, p: model, prototype.

INTRODUCTION

An interlocking compressed earth block (ICEB) is made by pressing local soil, mixed with a small amount of cement (usually 5 to 10 per cent), in a manual press. The block comes out with raised keys on top and matching recesses below, together with vertical holes, so that blocks stack onto each other like toy bricks. No mortar is needed, and steel bars with grout are added only where the design requires them [1]. Because the main raw material is soil from near the site, ICEB houses are inexpensive, need little transport, save energy compared with fired bricks or concrete, and can be built quickly by workers with basic training. Recent projects have even used computer-customized ICEB shapes for housing in low-resource regions [2]. For India, where affordable rural housing must often be built in earthquake-prone areas, this technology is directly relevant.

Almost everything known about how ICEB walls resist earthquake-type loading comes from a small number of full-size laboratory tests: in-plane cyclic tests on shear walls [3], out-of-plane tests on reinforced walls [4], tests on flexure-dominated walls [5], [6], a study of how block shape affects wall performance [7], a seismic design manual built on these results [8], and one full-size dry-stack building tested in South Africa under experimentally applied earthquake loading [9]. Every one of these programmes needed a strong floor, a heavy reaction frame, hundreds to thousands of blocks, and months of work. Very few institutions in the regions where ICEB houses are actually built have such facilities.

The usual engineering answer to this problem is to test a small-scale model instead of the real structure, the same idea as testing a model aircraft in a wind tunnel. This is already being attempted for earthen blocks: reduced-scale single-storey block building models have been tested on a shaking table in India [10]. The difficulty is that these tests reduced only the geometry. They did not follow any rules for scaling the weight, the friction, the key strength or the roof load, so their results cannot be converted back to full size with confidence. The only published study that scaled an interlocking earth-block structure rigorously used a geotechnical centrifuge, spinning additively manufactured model blocks at elevated acceleration [11]. That approach works, but a centrifuge is a rare national facility, so the accessibility problem remains.

This paper fills the gap. It derives, from first principles, the complete set of rules (the similitude framework) needed to test small models of dry-stacked ICEB walls in an ordinary laboratory. It identifies the three ratios that must be matched between model and prototype, shows how to correct the one unavoidable error (the reduced self-weight of the model) with simple added weights, explains how to handle size effects, and gives a practical recipe for making model blocks in 3D-printed moulds. A worked example at one-quarter scale, using only published full-scale data, shows that everything needed fits on a laboratory bench.

LITERATURE REVIEW

Three bodies of research meet in this work: how dry-stacked interlocking walls behave; how scale models are designed for other structures; and how strength changes with specimen size. A systematic Scopus search (ten queries, August 2026, combining interlocking, compressed earth block, dry-stack and mortarless terms with wall, shear and seismic terms, similitude, scale model and dimensional analysis terms, size-effect terms, and 3D-printed mould terms) returned 1,850 records, of which 1,783 were unique after removing duplicates. The sources below were all read in full text.

How dry-stacked interlocking walls behave

Laboratory characterization of dry-stack ICEBs shows that wall strength depends on four factors: the stabilized soil itself, the friction between block faces, the contact at the interlocking keys, and the geometry. Joint shear follows the Coulomb friction law, and the initial shear resistance comes from the interlock indentations rather than from any bond; in shear tests at low compression the indentations broke [1]. Measured peak friction coefficients on dry compressed earth block interfaces are high: values of about 1.20 and 1.07 were obtained for two stabilized mixtures, far above the value of 0.4 that Eurocode 6 proposes for mortared joints [12]. Machine-pressed stabilised soil blocks used for

structural applications in India are governed by IS 1725:2023, which specifies dimensions , compressive strength classes and physical requirements; no BIS provision yet addresses the design or seismic testing of dry-stacked interlocking walls, and the evidence that scale modelling generates is precisely what a future Indian provision would require. The vertical load a wall can carry depends on its slenderness and on how well the blocks actually touch [13], and the out-of-plane strength of dry-stack walls rises directly with the vertical load pressing the blocks together [14]. The same joint-controlled behaviour is seen in mortarless interlocking walls of other materials: such walls dissipate earthquake energy mainly by blocks sliding on each other [15], and a recent numerical simulation of an ICEB shear wall with dry vertical and horizontal joints confirms that the joint parameters control the response [16]. Two joint-level details matter especially. First, block faces are never perfectly flat, and this unevenness concentrates the contact and changes the capacity, so flatness is a real physical variable [17]. Second, cyclic friction tests on dry mortarless surfaces show that shear resistance varies linearly with normal stress, following the Mohr-Coulomb criterion without cohesion; within the tested range the friction coefficient is therefore constant [18]. This last fact, as the Methodology shows, is what makes small-scale testing of these walls possible at all.

The full-scale ICEB tests [3] to [8] also reveal something unusual: standard masonry design formulas transfer poorly to this system, and in different ways for different mechanisms. For the shear-dominated walls, the ACI 530 method significantly overestimated the measured in-plane shear capacity [3]. For the out-of-plane walls, the flexural strength was predicted adequately [6], but the stiffness was not: measured displacements were several times larger than the code predictions, the measured masonry modulus was 350 MPa (equal to 125 times the masonry strength, against the ACI 530 approximation of 700 times for clay masonry), the strain at peak prism strength was about 0.014 against typical code values of 0.0025 to 0.003, and a joint gap of 0.4 mm per course had to be introduced in the analysis to match the measured response [4]. In plain terms, these walls move by blocks rotating and sliding at the joints, not by the material stretching. That is exactly the behaviour that ordinary scaling rules, written for solid materials, cannot handle.

Scale-model theory and practice

The mathematics behind scale models is dimensional analysis, formalized by the Pi theorem: any physical relationship can be rewritten in terms of a small number of dimensionless ratios, and if a model matches the real structure in those ratios, it behaves in the same way [19]. Structural engineers have a standard handbook of such rules covering static and dynamic models, model materials, the well-known gravity problem of small models, and size effects [20]. For ordinary mortared masonry the practice is mature: a reinforced masonry building has been tested on a shaking table at a length scale of 1:3, selected from the dimensional and load capacities of the table [21]; methods exist to compensate small unavoidable rule violations, called distortions [22]; and researchers actively compare the practical modelling options of true replica, added mass, and accepted distortion [23]. All of this practice, however, assumes the wall behaves like a continuous material. No such rulebook exists for walls that act through dry friction and interlocking keys.

Size effects

Small specimens of brittle materials are, size for size, stronger than large ones. For masonry in compression this is well documented through prism and wallette testing [24]. Even the drift a wall can sustain before failing decreases as the wall gets larger [25]. For earthen walls specifically, testing at several scales showed that small specimens gave a cohesion of 0.0715 MPa while a full-scale two-storey wall (5.95 m by 6.20 m by 0.65 m) of the same material gave a much lower cohesion of 0.0139 MPa; small-scale specimens consistently overestimate shear strength [26]. In India, machine-pressed stabilised soil blocks for structural use are governed by IS 1725:2023 [27], which sets dimensional, strength and durability requirements for the unit but not for wall assemblies. Seismic guidance for earthen buildings is given separately in IS 13827:1993 [28], whose scope is expressly limited to earthen houses built without stabilisers such as cement or lime, and which therefore does not extend to cement-stabilised interlocking blocks. No Indian provision presently covers the seismic design or the scale-model

testing of dry-stacked interlocking walls, and evidence of the kind this framework generates is precisely what such a provision would require. A small-model method for earthen walls must therefore include measured corrections for size, not ignore them.

The gap

Putting these strands together: small-scale earthen-block testing is already attempted, but without rules [10]; the rules exist, but only for solid, mortared masonry [20] to [23]; and the single study at the exact intersection of compressed earth blocks, dry-stacking and scale modelling (one paper out of 1,783 found in the systematic search) relies on a centrifuge [11]. To the authors' knowledge, no published framework tells an ordinary laboratory how to build and test a valid small-scale model of a dry-stacked interlocking earthen wall. This paper provides that framework.

METHODOLOGY

What must be matched: the three governing ratios

Consider a dry-stacked interlocking wall described by its block length L, with block height, block width, key dimensions, wall height H and wall length all held in fixed proportion to L as geometric ratios; block strength f_b; modulus E; density ρ; friction coefficient μ between bed faces; key shear strength τ_k acting over key area A_k on block contact area A_c; vertical stress σ_v from self-weight and roof load; gravity g; joint gap $\hat{g}$; an applied lateral force F; the resulting movement δ; and, for dynamic loading, acceleration a and time t.

Table 1. Variables of the dry-stacked interlocking wall problem and their dimensions

Variable	Symbol	Dimension (M-L-T)
Block length (reference length)	L	L
Wall height; joint gap; displacement	H; $\hat{g}$; δ	L
Block strength; modulus; key shear strength; vertical stress	f_b; E; τ_k; σ_v	$M L^{-1} T^{-2}$
Density	ρ	$M L^{-3}$
Gravity; acceleration	g; a	$L T^{-2}$
Time	t	T
Lateral force	F	$M L T^{-2}$
Friction coefficient	μ	1 (dimensionless)

Table 1 lists the fourteen variables. Their dimensional matrix has rank three (M, L, T), so the Pi theorem [19] gives 14 − 3 = 11 independent dimensionless groups: the three geometric ratios H/L, $\hat{g}$/L and δ/L; the friction coefficient μ, which is dimensionless and enters the set directly; and seven mechanical groups, E/f_b, τ_k/f_b, σ_v/f_b, $\rho gL/f_b$, a/g, t^2g/L and $F/(f_bL^2)$. The physically meaningful ratios used below are formed from these by multiplication; in particular Π_2 combines τ_k/f_b, σ_n/f_b, μ and the geometric key-to-contact area ratio A_k/A_c. Three ratios govern the strength and failure mode of the wall:

$$\Pi_1 = \mu = \tau / \sigma_n \quad (1)$$

The friction between block faces. This decides when blocks start to slide on each other. In the same-material regime, the friction coefficient is matched automatically; it is also measured in calibration step (3).

$$\Pi_2 = \tau_k A_k / (\mu \sigma_n A_c) \quad (2)$$

Key strength compared with friction strength. This decides which happens first, sliding on the bed face or breaking of the keys, and therefore selects the failure mode. With the stress scale equal to one, this ratio is matched pointwise at every joint of the wall.

$$\Pi_3 = \sigma_v / f_b \quad (3)$$

Vertical load compared with block strength. This governs rocking, joint opening and crushing. It is the ratio the gravity distortion attacks.

The physical importance of these ratios is confirmed directly by experiments: dry joints obey the friction law with the keys supplying the initial shear resistance [1]; wall capacity rises with vertical pre-compression [14]; and axial capacity depends on the contact state [13]. Secondary ratios complete the set: the self-weight ratio $\rho gL/f_b$ (the source of the gravity problem, discussed below), the stiffness ratio E/f_b, the scaled joint gap $\hat{g}$/L (the analysis-derived full-scale gap is about 0.4 mm per course [4]), and, for dynamic testing, a/g and t^2g/L. If model and prototype share the same values of the three governing ratios, and the secondary ratios are respected or corrected, the model wall will reproduce the prototype

strength and failure mechanism at the properly scaled load, with deformation quantities interpreted subject to the size-effect corrections described below.

The one unavoidable error, and how to fix it

The simplest and most reliable way to build the model is from the same material: press the model blocks from the same stabilized soil as the real ones. Then the strength, the density and, because the sliding surfaces are the same material pair, the friction coefficient are all nominally the same, and Π_1 is matched. One qualification applies: because the model soil must be sieved to a scaled maximum particle size (see Experimental setup below), it is an approximation to the prototype material with a modified grading, and that is precisely why μ and the strength corrections are measured in the calibration sequence rather than assumed. With the same material, stresses in the model equal stresses in the prototype, so all forces simply scale with area: a model at scale λ = 1/4 needs only 1/16 of the testing force (Table 2).

One thing, however, does not scale: gravity. A quarter-scale wall is only a quarter as tall, so the squeeze that its own weight puts on the bottom joints is only a quarter of the real value. The model is too light for its strength. The centrifuge fixes this by spinning the model to raise the effective gravity [11]. Our framework, meant for ordinary laboratories, fixes it instead with added weights, following the established idea of artificial mass simulation [20] and explicit distortion compensation [22]. The rule is simple. Add, at the top of the model wall, a surcharge stress

$$\Delta\sigma = (1 - \lambda)\cdot\rho g H + \sigma_r \qquad (4)$$

where H is the prototype wall height and σ_r is the roof load the real wall carries. This makes Π_3 exactly right at the bottom joint, where walls usually fail. The joints higher up then carry slightly more relative load than in the real wall. This error is bounded, is quantified in the worked example, and can be removed when necessary by splitting the surcharge into small weights placed every few courses. Most importantly, the correction is safe: because the friction coefficient is constant over the working stress range [18], adding weights to fix Π_3 does not disturb Π_1. That single experimental fact is what makes small-scale testing of these walls at normal gravity valid. For dynamic (shaking-table) testing one further requirement applies: inertial similitude at acceleration scale one requires distributed added mass equal to $(1/\lambda - 1)$ times the structural mass of the model, attached along the height [20]; this added mass simultaneously supplies the gravity-stress correction described above.

Size-effect corrections

Even with the same soil, small pressed blocks tend to come out somewhat stronger than large ones, and small specimens overestimate shear strength [24], [26]. The framework does not assume these effects away; it measures them. Two correction factors are determined by test: κ_f (model block strength divided by prototype block strength, from compression tests) and κ_k (the same ratio for key shear strength). Because key shear is a brittle fracture process, its size dependence follows fracture-type size-effect behaviour rather than simple strength proportionality; the measured κ_k therefore stands in for a size-effect law, cannot be assumed equal to one, and may itself depend on λ. All strengths measured on the model are divided by the applicable κ before being reported at full scale, and deformation results carry the additional caution that drift capacities themselves decrease with size [25].

Experimental setup: making and checking the model blocks

Model blocks are pressed in 3D-printed plastic moulds, an approach already proven for scaled interlocking blocks [11]. The mould is simply the block shape in negative, printed with three requirements: every key and hole scaled by exactly λ, so that the failure-mode ratio Π_2 is preserved (block shape is known to strongly affect wall behaviour [7]); small draft angles of 2 to 3 degrees so blocks release cleanly; and a printed-face flatness better than the scaled joint gap, $\hat{g}_m = \lambda \times 0.4$ mm, because face unevenness genuinely changes capacity [17]. Because the compaction pressure needed to reach the prototype dry density is far beyond what an unreinforced polymer face can carry repeatedly, the printed part serves as a geometry-defining insert seated in a steel or aluminium sleeve, with the pressing load carried by the metal frame; insert flatness is re-verified at regular pressing intervals and the mould service life is recorded and reported. Two tolerances are controlled separately, both scaled by λ: the face flatness of the mould, and the standard deviation of pressed block

heights, because course-height variability, not mould flatness alone, generates the joint gaps observed at full scale [4]. Curing is matched to prototype practice: the same mix, the same humid-cure regime and the same total curing duration are used [3], [4], and every friction and key-shear test is carried out at a controlled and reported moisture content, because the strength and the friction of earthen materials are moisture-sensitive. Fig. 1 shows the block scaling concept. Pressing is mass-controlled: each charge of soil is weighed to the scaled block mass and pressed to the scaled height, reproducing the real block density. The soil is sieved so that the largest particle also scales (the 4 mm full-scale pulverizer limit [4] becomes 1 mm at quarter scale), and the moisture is set by the standard drop test [4]. A minimum-scale criterion follows from the sieving rule: the smallest key dimension of the model, equal to λ times its prototype value, must span at least five maximum particle diameters for the key to behave as a continuum element rather than a particle-count-dominated one; this is the limit given for model materials in established practice, where the ratio of the largest particle size to the smallest model dimension is required not to exceed one fifth [20]. For brittle key features a stricter margin of up to ten diameters is prudent. With a 1 mm maximum particle at quarter scale, this requires model key features of at least 5 mm (10 mm with the stricter margin), corresponding to prototype key features of at least 20 mm (40 mm); block geometries with finer keys sit at or beyond this bound at $\lambda = 1/4$, and smaller scale factors are then inadmissible with this soil. This criterion defines a minimum admissible scale for a given block geometry and soil, and it is one more reason the key-shear calibration of step (4) is mandatory rather than optional: the measured κ_k absorbs both the size effect and any fabrication effect near the bound.

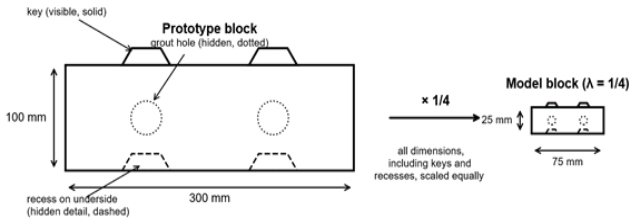


Fig. 1 Prototype and quarter-scale model block: every dimension, including the interlock keys, is multiplied by $\lambda = 1/4$. Key geometry is shown schematically; actual moulds follow the prototype block drawings.

Before any wall is built, five short calibration tests measure every quantity the framework needs, in the order shown in Fig. 2: (1) size, height-variability and flatness checks on the pressed blocks; (2) compression tests giving κ_f; (3) block-pair friction tests under a range of clamping pressures, analysed by the Mohr-Coulomb method of [18] and compared with the published full-scale values of about 1.07 to 1.20 [12]; (4) key shear tests giving τ_k and κ_k; and (5) prism (stacked block) compression giving the masonry strength and the joint-gap statistics (mean and coefficient of variation) for comparison with the full-scale value [4]. Minimum replication is prescribed: five blocks in compression, five friction pairs tested at no fewer than four normal-stress levels, five key-shear pairs and three prisms, with the mean and coefficient of variation reported for every parameter and the κ factors defined on means. Only when the three governing ratios are demonstrably matched does wall testing begin.

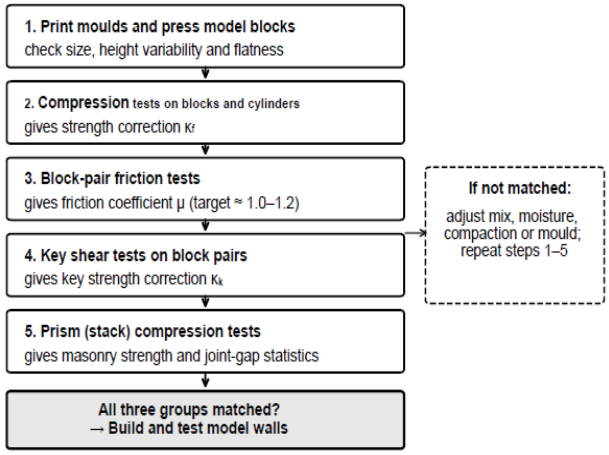


Fig. 2 The five-step calibration sequence: every contact parameter is measured before any wall is tested

RESULTS AND DISCUSSION

The scaling rules

Table 2 lists the complete set of conversion factors between model and prototype for same-material testing at ordinary gravity. Reading it practically: at quarter scale, lengths and movements shrink to one quarter, stresses and drifts stay the same, forces drop to one sixteenth, and specimen mass drops to one sixty-fourth. A wall test that needs a heavy reaction frame at full scale becomes a bench-top test.

Table 2. Conversion factors for same-material scale models of dry-stacked ICEB walls

Quantity	Scale factor (model/ prototype)	At $\lambda = 1/4$
Length, displacement	λ	0.25
Stress, strength, friction, drift	1	1
Force	λ^2	1/16
Mass	λ^3	1/64
Self-weight stress	λ (deficient; corrected by added weights)	0.25
Added surcharge	$\Delta\sigma = (1 - \lambda)\rho g H + \sigma_r$	see Table 3
Time / frequency (dynamic)	$\sqrt{\lambda}$ / $1/\sqrt{\lambda}$ (needs distributed added mass; see Methodology)	0.5 / 2.0

Worked example at quarter scale

The rules are now applied to the best-documented system in the literature: the 300 mm × 150 mm × 100 mm interlocking block with measured unit strength 7.76 MPa, grouted prism strength 2.81 MPa and modulus 350 MPa [4], with a minimum block dry density of 1850 kg/m³ (18.15 kN/m³) [3], adopted here as the block density, and a standard-block net-to-gross area ratio of 39,320/45,000 = 0.874 [4], built into an ungrouted dry-stacked wall of the same 1.8 m × 1.8 m × 0.15 m geometry as the shear walls of [3]. The example addresses the ungrouted configuration that the framework primarily targets; where grouted and reinforced walls are to be modelled, additional ratios enter (grout-to-block strength, reinforcement ratio and steel-yield-to-block-strength), the fully grouted density of 18 kN/m³ applies [4], and the scaling of reinforcement is a recognized further difficulty [20]. Fig. 3 illustrates the result and Table 3 gives the numbers. The model blocks measure 75 mm × 37.5 mm × 25 mm; the model wall is 450 mm square and 37.5 mm thick. The block density and the net-area ratio give an ungrouted wall unit weight of 0.874 × 18.15 = 15.9 kN/m³. The weight of the real wall therefore presses its base joints with 15.9 × 1.8 = 28.6 kPa; the model wall provides only 15.9 × 0.45 = 7.2 kPa; the difference of 21.4 kPa, acting on the model plan area of 0.45 m × 0.0375 m = 0.016875 m², requires a force of about 362 N, that is an added mass of about 37 kg (taking g = 9.81 m/s²), plus the scaled roof load where one exists. The soil is sieved to 1 mm, and mould flatness is held to 0.1 mm.

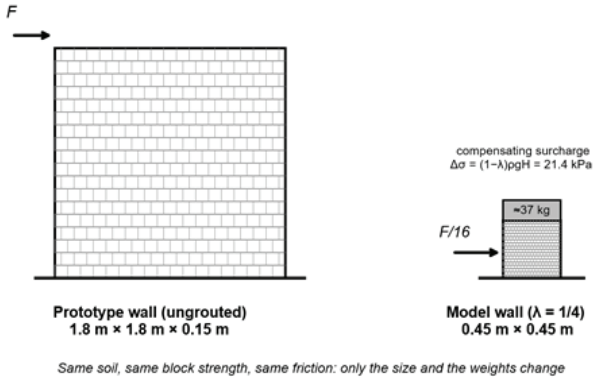


Fig. 3 The quarter-scale model of the reference wall: one sixteenth of the force, plus a 37 kg weight to restore the missing self-weight stress.

Table 3. Worked example: quarter-scale model built entirely from published full-scale data

Quantity	Prototype [3], [4]	Model ($\lambda = 1/4$)
Block (L × W × H)	300 × 150 × 100 mm	75.0 × 37.5 × 25.0 mm
Wall (L × H × t_w)	1800 × 1800 × 150 mm	450 × 450 × 37.5 mm
Block strength target	7.76 MPa	7.76 MPa (divided by measured κ_f)
Friction μ target	about 1.07 to 1.20 [12]	same (verified by test)
Joint gap / mould flatness	about 0.4 mm, analysis-derived [4]	0.1 mm or better
Largest soil particle	4 mm [4]	1 mm (sieved)
Wall unit weight (ungrouted)	15.9 kN/m³ (derived from [3], [4])	same material
Self-weight stress at base	28.6 kPa	7.2 kPa + 21.4 kPa added
Added weight on model	none	about 37 kg (+ scaled roof load)
Testing force	F	F/16

Three points deserve discussion. First, all three governing ratios can be satisfied at once, with entirely ordinary means: the same soil, a printed mould in a metal

sleeve, a bench press, and a 37 kg weight. The surcharge should be applied so that it follows the wall without restraining it, either as a gravity mass seated through a low-friction bearing or as a servo-controlled vertical force; with a gravity mass, the P-delta contribution of the concentrated weight approximates, but does not exactly reproduce, that of the distributed self-weight of the prototype, and the application method must be reported. Second, the one remaining error is known exactly. With a single top weight, the upper joints of the model carry up to 21.4 kPa more than strict similarity requires. Against a block strength of 7.76 MPa this is negligible (an error in Π_3 of about 0.003), but at very low clamping pressures it could slightly delay sliding at the top courses. If the expected failure involves those courses, for example rocking or out-of-plane bending, the weight should be split into smaller masses placed every few courses, exactly as the Methodology prescribes. Third, the mould-flatness target of 0.1 mm is the hardest requirement in the whole framework, and it must be treated as an acceptance check on every mould, because face unevenness genuinely changes how these walls carry load [17].

Comparison with other approaches, scope and limitations

Compared with the centrifuge route [11], the present framework trades perfect gravity scaling for accessibility, and replaces it with a correction whose size is known. Centrifuge results are in fact the ideal benchmark against which walls built under this framework should first be validated. Compared with geometry-only scaling [10], the framework adds precisely what was missing, namely the weight rule, the friction and key checks, and the size corrections, so that model results become transferable to full size. Because the three ratios come from joint mechanics shared by all mortarless interlocking walls, confirmed in interlocking brick [15] and reproduced numerically for ICEB walls [16], the framework extends, with re-calibration, to dry-stack interlocking masonry in general. Its limits are stated plainly. It covers quasi-static and moderate-rate loading; the dynamic extension by distributed added mass follows [20], [23] but is not demonstrated here. Small pressed specimens dry differently from full-size blocks, so moisture must be controlled and reported. The corrections κ_f and κ_k, and the caution that drift capacities decrease with size [25], [26], must always accompany any transfer of results. Equally, the framework guarantees similitude of strength and failure mechanism; stiffness and displacement quantities depend additionally on the joint-gap distribution, which the flatness and height-variability controls bound from above but do not reproduce statistically, so model deformations are transferred only together with the measured prism joint-gap statistics of step (5). Finally, the framework is proposed and analytically justified; its experimental validation is the natural next step, for which the calibration sequence of Fig. 2 is the ready-made programme.

CONCLUSIONS

This paper has derived the first set of rules for testing small-scale models of dry-stacked interlocking compressed earth block walls in an ordinary laboratory. The key findings are: (i) three dimensionless ratios govern these walls, namely the friction between block faces, the key-strength-to-friction ratio, and the vertical-load-to-block-strength ratio, and a model matching all three reproduces the strength and failure mechanism of the real wall; (ii) building the model from the same soil matches the friction ratio automatically, and the single unavoidable error, the deficient self-weight of the model, is corrected by an added weight computed from a one-line formula, a correction that does not disturb the friction ratio because friction in these joints is constant over the working stress range; (iii) size effects are handled by two measured correction factors built into a five-step calibration sequence, rather than by assumption; (iv) a quarter-scale worked example built on published data needs only a 37 kg weight, 1 mm sieved soil, 0.1 mm mould flatness and one sixteenth of the lateral testing force, placing meaningful ICEB wall research within reach of any institution with a bench press and a desktop 3D printer; and (v) 3D-printed moulds with weighed, height-controlled pressing give model blocks of faithful geometry at negligible cost. The novelty lies in extending scale-model theory from solid, mortared masonry to walls governed by friction and interlocking. Future work should validate the framework experimentally through the proposed calibration and wall tests, benchmark it against the published centrifuge results, and extend it to shaking-table testing using distributed added masses.

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