

DESIGN FOR RAIN'S SAKE

TRACING A RAINDROP'S JOURNEY THROUGH LANDSCAPE AND COMPUTATIONAL DESIGN

ABSTRACT

THIS RESEARCH INVESTIGATES HOW COMPUTATIONAL TOOLS CAN SUPPORT ARTFUL RAINWATER DESIGN (ARD), AN APPROACH THAT MERGES STORMWATER MANAGEMENT WITH VISUAL AND EDUCATIONAL VALUE IN LANDSCAPE ARCHITECTURE. FOCUSING ON SMALL-SCALE HYDROLOGY IN URBAN CONTEXTS, WE EVALUATED APPROXIMATELY 20 SOFTWARE PLATFORMS AND SELECTED THREE—FLOW-3D HYDRO, AUTODESK CFD, AND BLENDER—FOR DETAILED SIMULATION ANALYSIS. USING A CUSTOM "FLOW BOX" SETUP, WE TESTED FLOW BEHAVIOR INCLUDING SPLASH DYNAMICS, RATE CHANGES, AND WATER VISUALIZATION. THE STUDY ALSO PRESENTS A NARRATIVE FRAMEWORK TRACING A RAINDROP'S JOURNEY THROUGH FIVE DESIGN SCENARIOS, FROM NATURAL INFILTRATION TO HIGHLY DESIGNED ARD SYSTEMS, TO HIGHLIGHT BOTH ECOLOGICAL AND EXPERIENTIAL OUTCOMES.

BY COMPARING DIGITAL SIMULATIONS WITH RESULTS FROM PHYSICAL MODELS, WE ASSESS EACH TOOL'S ABILITY TO INFORM RESILIENT, EXPRESSIVE WATER DESIGN. FINDINGS DEMONSTRATE THAT COMPUTATIONAL MODELING, WHEN PAIRED WITH DESIGN INTENT, CAN ENHANCE BOTH THE FUNCTIONAL PERFORMANCE AND COMMUNICATIVE POWER OF ARD IN SMALL-SCALE URBAN HYDROLOGY.

INTRODUCTION

ARTFUL RAINWATER DESIGN (ARD) INTEGRATES STORMWATER MANAGEMENT WITH VISUAL AND EDUCATIONAL EXPERIENCES. IN URBAN SPACES, SMALL-SCALE HYDROLOGY LIKE RUNNELS PLAYS A VITAL ROLE. THIS RESEARCH EXPLORES HOW COMPUTATIONAL SIMULATIONS CAN HELP DESIGNERS PREDICT WATER FLOW AND OVERFLOW, ENHANCING BOTH THE PERFORMANCE AND EXPRESSION OF ARD FEATURES.

METHODS

WE BEGAN BY REVIEWING OVER 40 SIMULATION TOOLS BASED ON CFD CAPABILITIES, ANIMATION, USABILITY, AND ACCESSIBILITY. THREE WERE SELECTED FOR DETAILED TESTING: FLOW3D HYDRO, AUTODESK CFD, AND BLENDER. FOCUSING ON RUNNELS, WE CONDUCTED 30 PHYSICAL EXPERIMENTS AND 30 MATCHED SIMULATIONS, VARYING SLOPE, DEPTH, AND FLOW RATE. CONSISTENT BOUNDARY CONDITIONS ENSURED COMPARABILITY. FINAL RESULTS—including video comparisons of physical and digital outcomes—are accessible via a QR CODE FOR TRANSPARENT VALIDATION AND BROADER DESIGN APPLICATION.

RESULTS

FLOW3D HYDRO ACCURATELY SIMULATED OVERFLOW PATTERNS, ALIGNING WITH PHYSICAL EXPERIMENTS. BLENDER OFFERED VISUAL CLARITY BUT LACKED PRECISION. AUTODESK CFD FAILED UNDER COMPLEX CONDITIONS. DIFFERENCES BECAME CLEARER WITH STEEPER SLOPES AND HIGHER FLOW RATES. SIDE-BY-SIDE SIMULATION AND EXPERIMENT VIDEOS ARE SHARED VIA QR CODE FOR PUBLIC REVIEW AND EDUCATIONAL PURPOSES.

CONCLUSION

FLOW3D HYDRO PROVED MOST RELIABLE FOR MODELING SMALL-SCALE HYDROLOGY IN ARD. SIMULATIONS VALIDATED BY PHYSICAL TESTS ENHANCE DESIGN CONFIDENCE. WHILE BLENDER AIDS VISUALIZATION, ONLY CFD TOOLS PROVIDE NECESSARY ACCURACY. THIS INTEGRATED APPROACH SUPPORTS DESIGNERS IN REFINING OVERFLOW-SENSITIVE FEATURES LIKE RUNNELS, ALIGNING TECHNICAL PERFORMANCE WITH THE EXPRESSIVE GOALS OF ARD.

THE WILD DROP PURE NATURE

THE WORKING DROP FARM LANDSCAPE

THE CELEBRATED DROP ARTFUL RAINWATER DESIGN (ARD)

THE FORGOTTEN DROP NO URBAN INFRASTRUCTURE

THE HIDDEN DROP CONVENTIONAL GRAY INFRASTRUCTURE

- FALLS ON FOREST, MEADOW, OR WETLAND
- INFILTRATES NATURALLY, SUPPORTS ECOSYSTEMS
- RECHARGES GROUNDWATER AND EVAPORATES CLEANLY
- MOVES SLOWLY, IN BALANCE WITH THE ENVIRONMENT
- OUTCOME: NATURAL FILTRATION, NO RUNOFF
- DESIGN INVOLVEMENT: NONE – ENTIRELY ECOLOGICAL

- LANDS ON FIELDS, PASTURE, OR CROPLAND
- HELPS CROPS GROW IF SOIL ABSORBS IT WELL
- CAN CAUSE RUNOFF WITH SEDIMENT, FERTILIZER, PESTICIDES
- DEPENDS ON SLOPE, SOIL HEALTH, AND MANAGEMENT
- OUTCOME: USEFUL OR HARMFUL DEPENDING ON PRACTICE
- DESIGN INVOLVEMENT: FARM BMPs (E.G., CONTOUR FARMING, SWALES)

COLLECTS AND CONDUCTS RAINWATER



POROUS PAVEMENTS



RAIN BARRELS



WATER WALLS



SCULPTURAL CISTERNS



ROOFS

- GLIDES THROUGH RUNNELS, NOURISHES PLANTINGS, FORMS POOLS
- SEEN, HEARD, AND TOUCHED BY PEOPLE
- SLOWED, FILTERED, AND REUSED WHERE POSSIBLE
- BECOMES PART OF AN EDUCATIONAL AND AESTHETIC EXPERIENCE

"ARD INTEGRATES FUNCTION AND BEAUTY..." – ECHOLS & PENNYPACKER

- **SIMULATIONS:** FLOW-3D, CFD TOOLS GUIDE FLOW BEHAVIOR AND OVERFLOW CONTROL
- **OUTCOME:** SUSTAINABLE, BEAUTIFUL, AND ENGAGING
- **DESIGN INVOLVEMENT:** HIGH – CREATIVE, INTERACTIVE, DATA-INFORMED

HOW TO EVALUATE?

VISIBLE ENGAGING



EXPOSED PIPES



RUNNELS



SPLASH PADS

INTEGRATED INTO THE LANDSCAPE



BIOSWALES



RAIN GARDENS

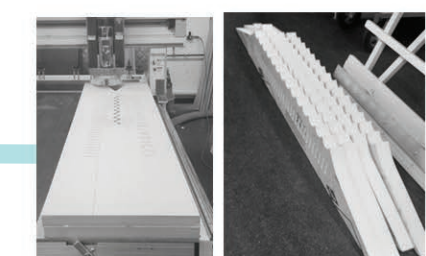


WETLANDS

PHYSICAL EXPERIMENTS PROVIDED TANGIBLE, REAL-WORLD INSIGHT INTO OVERFLOW BEHAVIOR, CAPTURING SPLASH EFFECTS AND MATERIAL RESPONSES THAT SIMULATIONS OFTEN MISS. THEY OFFERED HIGH ACCURACY BUT REQUIRED SIGNIFICANT TIME, LABOR, AND SETUP. WHILE EFFECTIVE FOR VALIDATION, PHYSICAL TESTING LACKS FLEXIBILITY AND SCALABILITY, MAKING IT LESS EFFICIENT FOR EXPLORING MULTIPLE DESIGN VARIATIONS.

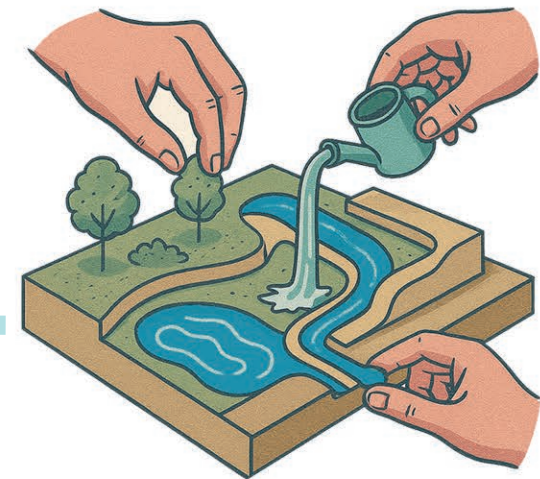


YOUTUBE VIDEO
PHYSICAL EXPERIMENT



BUILD THE MODEL AND CONTROL
THE EXPERIMENT SPACE

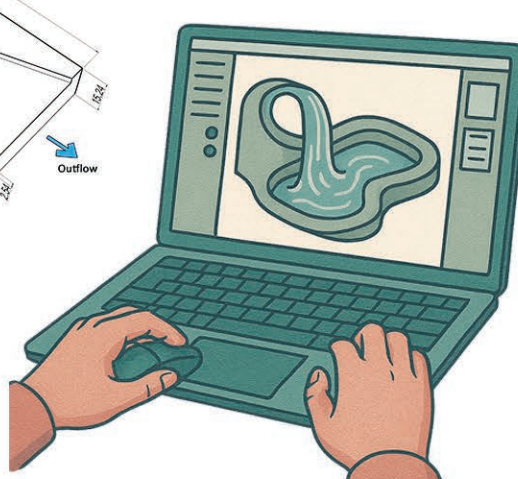
PHYSICAL EXPERIMENTS



PREPARE THE
MODEL



COMPUTER SIMULATIONS



SIMULATIONS ALLOWED RAPID TESTING OF VARIED CONDITIONS, OFFERING FLEXIBILITY AND VISUAL FEEDBACK. FLOW3D HYDRO DELIVERED PRECISE, CONSISTENT RESULTS, WHILE BLENDER EXCELLED IN VISUAL STORYTELLING BUT LACKED TECHNICAL CONTROL. AUTODESK CFD STRUGGLED WITH ACCURACY. THOUGH SIMULATIONS SAVE TIME AND RESOURCES, THEY DEPEND HEAVILY ON SOFTWARE CAPABILITIES AND PROPER CALIBRATION.



CHOOSE A SIMULATOR CONSIDER
ITS PERFORMANCE



YOUTUBE VIDEO
COMPUTER SIMULATION