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Evaluating Soft Robotics in High – Performance Adaptive Facades

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ABSTRACT

Old-school kinetic architecture uses clunky motors and joints, which can break down a lot and cost a lot to keep running. This paper looks at moving toward flexible systems, like Soft Robotics and Shape Memory Alloys (SMA). We checked how strong they are and how long they last, suggesting we switch from big mechanical movements to changes at the material level. *Keywords – Adaptive Facades, Soft Robotics, Shape Memory Alloys.

1.INTRODUCTION

Building design has come a long way from just throwing up walls. Now, facades are more like living skins that adjust to keep things comfy inside, no matter what's happening outside. Instead of just using solid stuff, modern buildings use smart materials to control energy, light, and air flow. The Problem: Kinetic systems with moving parts often break because of the wear and tear. Plus, they eat up a lot of energy.

The Question: Can soft robots and smart materials be a better, longer-lasting, and more energy-friendly option than regular motors and gears?

What We Want To Do:

1. Make a list of smart materials used in facades.

2. See how a soft robot muscle stacks up against a steel hinge in terms of strength.

2. LITERATURE REVIEW

Rigid Kinetic Systems of the Past: We are going to look at buildings like the Institut du Monde Arabe (Jean Nouvel) and the snags it ran into with its camera-iris system.

What's New in Smart Materials:

Shape Memory Alloys (SMA): These materials go back to their original shape when you heat them up.

E**lectro-Active Polymers (EAP)**: Artificial muscles that get bigger or smaller when you zap them with electricity.

Copying Nature: The Flectofin (inspired by the Bird of Paradise flower) was one of the first to move without hinges.

3. RESEARCH METHODOLOGY

We ran a comparison: We looked at a regular folding shutter system next to one that uses SMA. This comparison shows how building skins are going from stiff barriers to living systems. Regular Shutters vs. SMA Shutters What We Learned:

Energy: Regular motors use power all the time, but SMA systems can be made to work passively, using heat from the sun to change shape without needing extra power.

Noise: SMA systems are quiet, which is great for fancy homes or offices.

How it Fits Together: SMA systems let you make facades that are seamless. Since there aren't any hinges, the shutter can be one continuous, bendable surface, which makes the building more airtight and better insulated.

4. ANALYSIS

Comparing traditional mechanical systems with smart materials (SMA/Soft Robotics) shows a move away from complicated parts toward built-in function.

Complexity: Regular motorized setup are complex because they use a lot of things. Smart materials are

easier because the movement is already part of what they are.

Maintenance: Mechanical systems need grease and replacement parts all the time. Smart materials need tough testing at the start, but not much after that.

Size: Mechanical parts are usually heavy and are made of metal. Smart materials are light and use thin wires and polymers to cut down on bulk.

Movement: Traditional systems move in straight lines or steps, but smart materials move smoothly.

5. DISCUSSION: STRUCTURAL IMPLICATIONS

Can we make this bigger?

Problem of use soft systems to move the big glass pannels.

Weather Damage: UV radiation and temperatures might harm soft robotics.

Silent Facades: Taking out motors removes the electric humming in favor of quiet material deformation.

6. CONCLUSION

Simply said: Using new materials simplifies kinetic setup and removes the most weak spots.

Future: We can use 4D printing to create facades that leave the factory with kinetic system ready to go.

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7. REFERENCES

Addington, M., & Schodek, D. (2005). Smart Materials and Technologies.

Knippers, J., et al. (2011). Bio-inspired kinematically active metal structures.

Lignarolo, S., et al. (2011). Adaptive building envelopes: State of the art.