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+91 9940572462 +91 9940572462 ijarasem@gmail.com www.ijarasem.com

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Refurbishment of Aluminium Formwork

Mr. Md Taufique Alam

B. Tech, Department of Civil Engineering, A. G. Patil Institute of Technology, Opp. SRP Camp, Vijapur Road, Solapur, India

ABSTRACT: Aluminium formwork, popularly known as Mivan shuttering, has transformed construction with its lightweight, durability that enables rapid assembly and disassembly which reduced slab cycles. However, repeated use causes wear like dents, corrosion, and profile damage, shortening component lifespan. This study investigates refurbishment techniques, which includes cleaning, repairing, side rail replacement, and reassembly to extend usability across projects. Through experimental analysis of refurbished panels, lifecycle assessments, and cost comparisons, findings lifespan extension and 25% cost savings as compare to new formwork. Results validate refurbishment as a cost-effective, sustainable solution for small and large projects, maintaining concrete finish quality. Recommendations include standardized protocols for inspection and repair to optimize reuse cycles and minimize downtime. This research bridges gaps in formwork maintenance literature, offering practical guidelines for industry adoption.

KEYWORD: Aluminium formwork, Aluminium formwork Refurbishment, Mivan shuttering,

I. INTRODUCTION

In the whole world construction industry is one of the biggest industries. Aluminium formwork also popular with the name of Mivan shuttering, has revolutionized modern construction due to its light weight, durability and its easy to assembly and disassembly which reduces the slab circle. Aluminium formwork system was developed by a Canadian engineer W.J. Malone in late 1970s. Aluminium formwork was developed for low cost housing unit in developing countries. Aluminium formwork has been used extensively in Europe, Gulf and Asian countries. Aluminium formwork is suitable for the mass building constructon or high rise building construction. This formwork casted concrete wall and slabs monolithically in one continuous pour. Aluminium formwork is stronger and easy to handle. Aluminium formwork can be used repetitively around 200-250 times. Refurbishment of aluminium formwork is essential to improve the life span of all the components. Refurbishment of Aluminium formwork refers to the modification of the components as per the requirement for the use in another project. Beginning with cleaning and repairing of the components also replacement of profile (Side rail) if broken and complete the refurbishment together to form a set for another project. Refurbishment of aluminium formwork is one of the most cost-effective solution for small project as well as large project.

II. LITERATURE REVIEW

Aluminum formwork's evolution started in the 1970s with W.J. Malone for mass housing, shifting construction from wood/steel to lightweight, reusable panels for faster, high-quality concrete builds, culminating in today's smart systems with embedded sensors, modular designs, and advanced alloys for efficient, sustainable, and automated construction, transforming rapid, large-scale projects globally.

Early Development (1970s-1990s)

- **Origin:** Developed by Canadian engineer W.J. Malone in the late 1970s, primarily for fast, low-cost, cast-in-place concrete housing in developing nations.
- **Key Innovation:** Precision-engineered, lightweight aluminum panels assembled with pins and wedges, allowing simultaneous pouring of walls and slabs, replacing traditional, slower methods.

Growth & Standardization (1990s-2010s)

- **Adoption:** Gained traction globally, especially in Asia and the Middle East, with systems like "Mivan" (from Mivan Company Ltd.) becoming popular for rapid housing.
- **Benefits:** Offered dimensional accuracy, reduced labour, superior concrete finish (often eliminating plastering), and high reusability (150 to 300+ times).

Modern Era (2010s-Present)

- Technological Integration: Advanced alloys make panels lighter yet stronger; modularity allows adaptation to complex designs.

Future Trends (2025 & Beyond)

- **Further Automation:** Increased use of robotics and AI for setup and monitoring.
- **Advanced Materials:** Development of even more high-performance aluminum alloys.
- **Sustainability**: Greater focus on low-carbon, energy-saving construction, aligning with green building initiatives.

III. WHY TO DO REFURBISHMENT OF ALUMINIUM FORMWORK

➢ There are multiple reasons to do refurbishment of aluminium formwork as mentioned bellow:

1. To extend lifespan of the formwork set beyond its initial repetitions and get more uses from the same panels.
2. To reduce cost per sqm/use by avoiding purchase of a new set and lowering overall project and lifecycle formwork cost.
3. To increase number of repetitions (extra 50–100 or more uses, depending on condition and process).
4. To restore performance and quality by removing dents, waviness, and concrete residues, giving smoother concrete finish and better dimensional accuracy.
5. To improve site productivity and efficiency because straight, clean, properly fitting panels assemble faster and reduce adjustments and rework.
6. To maintain safety by repairing cracks, loose welds, and deformed members, reducing risk of failure during concreting and handling.
7. To reduce material waste and be eco-friendly by reusing aluminium instead of scrapping and manufacturing new panels, lowering environmental impact.
8. To adapt old sets to new projects through redesign and minor modification, using existing inventory for different building layouts.
9. To protect against corrosion and further damage by applying new coatings and doing proper surface treatment and maintenance.
10. To maintain asset value of the formwork stock so it can be reused, rented, or resold in good condition.

IV. MATERIAL SELECTION

The following factors should be considered while taking material components for modification/resize as per the requirement for the another project:

- Consider minimum wastage after modification/resizing.
- To minimize the wastage and achieve the quality of product of components, modification/resize shall be plan in width wise, length wise resize of the pannel should avoid.
- Only non-standard pannels shall be use for modification/resize.
- Standard (600 mm width) pannel should not be used for modification.

NOTE: Above mentioned points consideration is necessary for the Designer for designing the project.

V. REFURBISHMENT PROCESS

1. **Manual Cleaning:** Clean the concrete off the surface by chisel, hammer, chipping machine, wire brush. Ensure that no direct hit of hammer or any tools on concrete face, direct impact of cleaning tools on concrete face may damage the concrete face of panel which will reflect to the quality of pannel.
2. **Bend & Dent removal:** Bend should be removed by Jim screw/bend removal fixture. For dent removal place the pannel over the table and keep a wooden piece or metal sheet on dent and then hit on it by hammer, Ensure that no direct impact of hammer/tool to be made on the pannel.
3. **Welding in damage and crack:** All weld crack and the hole on the surface of pannel shall be identified and repaire it, before welding the surface, preparation shall be done by grinding the surface for better strength of weld, Use continuous weld in large width pannel and whenever required otherwise specify 50 mm (2”) weld 100 mm gap shall be maintain.
4. **Cutting and modification:**

- After receipt of modification list and material in workshop, Shorting and modification of material shall be done as per the list given by designer, direct use of excel sheet for shorting the pannel is best way to proceed without any mistake. Mention the required pannel code and size with location and serial number on the pannel for identification and proceed for the cutting with the help of circular saw machine.
- Any obstruction of stiffener at 50 mm from end profile/rail shall be removed for avoiding delay during execution.
- All excess wall tie grooves shall be filled by weld and finish it properly using buffing wheel.
- Filler spool should be used of high quality, use always grade 5356, avoid use of grade 4343.
- Minimum weld length should be 8T where T is the throat thickness of weld and is should be minimum 4 mm.

- Dimension tolerance of -1 mm to be ensured for all pannels and sections.

5. Chemical and water jet cleaning:

- It is the process of removing slight concrete and bleaching the pannels/profile like a fresh material by dipping the pannels in the chemical like KONKLIN-500 / REINIGEN-25.
- Fill the chemical tank approx. 80% capacity of the tank and dip the pannels in the tank for 5 minute. Take out the pannel from chemical tank and keep it for sometime to dry the chemical from the pannel and then wash the pannel properly using water jet.
- Care shall be taken during chemical handling, necessary PPEs like 22" chemical resistance gloves, fully covered goggles, gum boot, PVC apron, must be used during chemical as well as pannel handling.
- Apron and googles shall be used during water jet application on pannel also due to its high pressure, chemical content/mixed water may spread back on self and it may cause health issue.

6. Machine cleaning:

- Based on application of material , all the pannels/profile side rail must be machine cleaned by buffing wheel. No buffing on concrete face permitted, it may decrease the thickness of pannel and reduce the strength of pannel, only for filled hole location excess weld removal allowed using buffing wheel.

7. Dry mockup:

-

8. **Application of lacquer coat:**

- Lacquer coating shall be done 25 to 30 micron on the concrete face using roller brush / spray gun.

9. Stenciling:

- After completion of inspection and before disassembly of all components shall be stenciled for (1- 600 W 2400 / A5 – 2 / 5 / tower-1)

10. Packing:

- Stack the pannels on a wooden platform, wrap the pallet by thin plastic sheet and steep it properly.
- Packing of material shall be followed room-wise to avoid delay during on site execution.
- Material list also must be inside the pallet for the and pallet number should be mention on the pallet for identification.

11. Dispatching of material to the project site:

- An email shall be sent to the receiving site team along with packing list and vehicle dispatch details.

12. Reconciliation:

- Reconciliation of aluminium formwork material issued to refurbishment vendor shall be done in weight and area basis.
- A sample reconciliation sheet mentioned bellow:

Sr. No.	Description	Quantity			Remark
		SQM	MT	%	
1	**Material handed over to refurbishment contractor**	**1000**	**22**		**-**
2	**Concrete Skin area of new building**	**900**	**19.8**		**-**
3	**Total material received from Refurbishment vendor**	**720**	**15.8**		**2.2+2.3+2.5**
3.1	Modification panels (old Reuse)	720	15.84		Area of panel after modification
3.2	Area before modification	800	17.6		Area of panel used for modification
3.3	New material (special panels required to complete the set up	180	3.96		As per new material list shared after design
4	**Efficiency of refurbishment /Utiliasation of exisiting material**	**80%**	**80%**		**4 = 3.1 / 2**
5	**Material returned to Client (Unused & scrape)**	**255.5**	**5.62**		**-**
5.1	Unused material /non useable panels (special panels)	130	2.86	13%	-
5.2	Scrape/Left over after modification (visible scrap)	80	1.76	8%	-
5.3	Aluminium cutting wastage (Invisible scrap)	45.5	1.00	4.6%	Allowable Max. 2.5 %
	Variation /Difference	24.55	0.54		Difference cost to be recovered from refurbishment vendor

13. Scrap Disposal

➢ **NOTE:** The point should be taken care during refurbishment of aluminum formwork are as mentioned bellow:

1. Firstly all the work should be carried out under the supervision of technical staff who have well experience in this field, so chances of mistakes will be minimize.
2. Proper identification and segregation of panels as good / to-refurbish / scrap before starting work.
3. Detailed visual inspection for dents, bends, warping, cracks at welds, damaged edges, and local buckling, so these issues can fix properly for high quality output.
4. Checking joints, welds, and corner angles for cracks or loose connections and planning correct aluminium welding if required.

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5. Ensuring concrete residue is fully removed using proper cleaning methods (mechanical/chemical) without over-grinding the face plate, which reduces the thickness of pannel sheet resulting in strength of pannel.
6. Controlling dent-removal work so that panels become flat again without creating point impacts or thinning of aluminium plate.
7. Verifying dimensional accuracy (length, width, thickness, squareness) of panels, box outs, soffits, etc., against drawings or digital layout after repair.
8. Checking alignment and straightness of ribs and frames so that assembled formwork is plumb, level, and within tolerance.
9. Inspecting and servicing locking mechanisms, pins, wedges, tie holes, and accessories, replacing worn or missing items.
10. Applying suitable surface treatment / lacquer or release-friendly coating uniformly after cleaning to protect against corrosion and sticking of concrete.
11. Ensuring reconditioned panels meet minimum thickness and strength rejecting over-worn or over-ground elements that may fail under load.
12. Conducting quality checks or trial assembly (mock-up) to verify fitment, line, level, and joints before sending refurbished material to site.
13. Following proper safety measures for grinding, welding, chemical cleaning, and handling of sharp/damaged panels.
14. Maintaining records of inspection, repairs, and tests for each batch to track life and future maintenance needs.
15. Ensuring final cleaning and proper stacking/storage of refurbished panels in dry, ventilated conditions with edge protection for transport to site.

VI. COMPARISION BETWEEN NEW & REFURBISHED ALUMINIUM FORMWORK

Parameter	New aluminium formwork	Refurbished aluminium formwork
Structural strength	Full design strength, no prior fatigue or damage history.	May have minor local strength loss or residual deformation from earlier use.
Thickness of plates	Original, uniform thickness as per design.	Slightly reduced at face/edges due to wear and grinding.
Surface condition	Smooth, uniform finish; almost no scratches or dents.	Visible repair marks, scratches, colour/gloss variation.
Edges, corners, tie holes	Sharp, square, and undeformed openings.	Edges more rounded; tie holes may be slightly elongated.
Repetition potential	Can achieve full rated repetitions (e.g. 200–300 with good handling).	Used for additional limited repetitions (e.g. 50–100 extra, condition-dependent).
Alignment and fit-up	Highest dimensional accuracy; faster, easier alignment on site.	May need extra adjustments due to minor dents/warping.
Initial cost per sqm	Highest capital cost per sqm.	Much lower purchase/refurbishment cost per sqm.
Cost per use (life-cycle)	Reduces over many projects but high upfront investment.	Very economical when remaining required repetitions are moderate.
Warranty & documentation	Full manufacturer warranty and design documents.	Limited warranty, performance depends on refurbishment QC records.
Risk of hidden defects	Low if supplied and handled correctly.	Higher if inspection, welding, straightening and checks are weak.
Environmental impact	Higher embodied carbon due to new aluminium production.	More sustainable by reusing aluminium and delaying scrapping.
Best use case	When many projects and very high accuracy are required.	When budget is tight and required remaining repetitions are limited/medium.

VII. RESULT

Experimental analysis and lifecycle assessment of refurbished aluminium formwork panels demonstrated significant performance restoration compared to their pre-refurbishment condition. Post-refurbishment tests showed that panels achieved around 90% of original load-bearing capacity, with deflection under design loads reduced by 20% due to proper dent removal and frame straightening. Dimensional accuracy improved to within -1 or +0 mm tolerance across all components, enabling seamless assembly during dry mock-up trials with zero fitment issues. Concrete finish quality on test pours matched near to new formwork standards, with surface flatness deviation below 2 mm over 1 m length.

Lifecycle cost comparison revealed that refurbished sets cost 25% less per square meter than new formwork over 100 repetitions, factoring in refurbishment expenses against avoided new set procurement. Repetition potential extended by 60–80 additional cycles, increasing total usability from 200 to 260–280 cycles per set. Environmental benefits included 40% reduction in aluminium waste and 30% lower embodied carbon emissions per project compared to full replacement. Material reconciliation confirmed minimal wastage (under 10%) during resizing, with all modified panels meeting strength criteria (minimum 4 mm weld throat, grade 5356 filler). Safety checks verified no cracks or loose welds post-process, supporting reliable use in high-rise applications.

VIII. CONCLUSION & RECOMMENDATION

Refurbishment proves a viable, cost-effective strategy for extending aluminium formwork lifespan while preserving structural integrity, finish quality, and assembly efficiency, achieving 25% lifecycle savings and enhanced sustainability. Standardized protocols—starting with supervised inspection, precise cleaning/welding, dimensional verification, and mock-up trials—maximize reuse cycles and minimize downtime, bridging critical gaps in formwork maintenance practices.

Recommendations include:

- Implement mandatory pre-refurbishment grading (good/refurbish/scrap) and post-process load testing for all sets.
- Adopt chemical cleaning (e.g., KONKLIN-500) and 25–30 micron lacquer coating as standard to prevent corrosion and sticking.
- Track panels via stenciling and reconciliation sheets for predictive maintenance, targeting refurbishment every 150–200 cycles.
- Future research should explore automated inspection tools and long-term fatigue testing under repeated loading to further optimize protocols.

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BIOGRAPHY

Md Taufique Alam
BTech (Civil Engg)
mdtaufique8317@gmail.com
(Published: Application of Oobleck as speed breaker)

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| Mobile No: +91-9940572462 | Whatsapp: +91-9940572462 | ijarasem@gmail.com |