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Laboratory 129 Safety Report

Rotating Climbing Surface Construction and Testing

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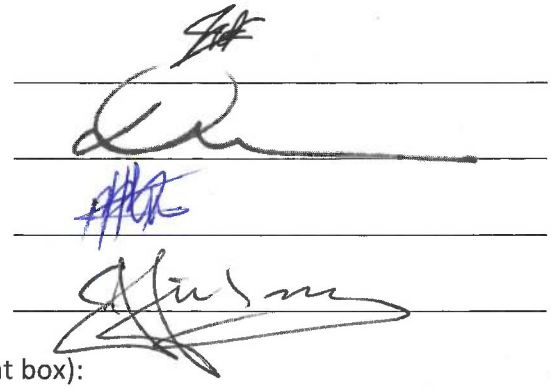

Pressure vessels or pipes (check relevant box):

☒ No pressure vessels or pipes with pressure in excess of 50kPa are involved in this project.

☐ Pressure vessels or pipes in excess of 50kPa are involved – additional signature and report required (refer to Safety Report Guidelines on SUNLearn).

Hot work / working at heights / confined entry / excavation (check relevant box):

☒ No hot work / working heights / confined entry / excavation work involved in this project.

☐ Hot work / working heights / confined entry / excavation work (underline relevant work type(s)) involved in this project – additional signature and report

Concept Description

A rotating climbing surface simulator is to be built. The base structure is a frame welded from square steel tubing. All cutting and welding is already done by the M&M workshop. The main climbing surface assembly is mounted through a shaft and two pillow block bearings to the base frame. This allows the climbing surface to tilt. The main climbing surface is constructed from 4 steel tube uprights, fastened together by laser cut steel plates and brackets. Two steel crossbeams at the top and bottom of the climbing assembly keep the left and right upright assemblies together and are the mounting points for the majority of the moving parts. Two conveyer chains run vertically, rotating an array of plywood panels, on which the climbing holds are mounted. The rotation of the system is powered by the weight of the user, and an electric servo motor is used to control the speed via electromagnetic braking. The climbing assembly tilts through use of a large, curved rack and pinion system, powered by a stepper motor. Figure 1 below shows a CAD representation of the final system.

Figure 1: CAD Design Overview

Manufacturing

Overview of Construction Activities

This section describes construction activities involved in the project, which include the assembly of steel tubing, using fasteners and laser cut brackets, as well as electrical work for the motion aspect of the project. Sanding will be performed to sharp edges.

Equipment to be used in the assembly of the rotating climbing wall

- **Angle Grinder:** Smoothening rough/sharp edges (cannot be used without necessary PPE and permissions).
- **Screwdriver Set:** Tightening screws.
- **Allen key set:** Tightening bolts.
- **Socket wrench set:** Tightening bolts.
- **Adhesive:** Securing limit switches etc.
- **Soldering Iron:** Soldering electronics.
- **Side cutters:** Cutting wire for electronics.

Manufacturing Risks

The following table outlines the manufacturing risks that could be faced during the manufacturing process. The key below table 1 provides more information on the abbreviations used in the title block of table 1.

Table 1: Manufacturing Risks

Activity	Risk	Risk Type	Mitigating Steps	(L)	(E)	(C)	Risk Score (R = L * E * C)	Risk Classification
On entry	Slips, trips, and falls	P	Ensure walkways are clear of debris and spills. Use appropriate footwear.	3	3	2	18	Possible
Initial workshop entry	Exposure to ongoing operations	P	Make presence known. Wait for operations to pause if necessary.	2	3	2	12	Possible
Sanding/Using tools	Inhalation of harmful dust or fumes	P	Ensure proper ventilation. Use respiratory protection if required.	1	1	2	2	Acceptable
Using common areas	Injury from improperly stored tools/equipment	P	Store tools and equipment properly after use. Conduct regular inspections.	3	2	2	12	Possible

Using power tools	Electric shock from faulty equipment	P	Regularly inspect common equipment for wear and damage.	1	1	4	4	Acceptable
Using power tools	Cuts/Burns	P	Regularly inspect common equipment for wear and damage. Use with caution.	2	2	3	12	Possible
Handling electrical motors	Electric shock	P	Ensure power is disconnected before handling. Use insulated tools.	3	2	4	24	Very High Risk
Working with steel beams	Cuts from sharp edges	P	Wear protective gloves. Deburr edges after cutting.	3	2	2	12	Possible
Working with steel beams	Drop beam onto self	P	Use a crane to lift heavy beams that you are unable to lift by yourself. Wear steel capped boots.	2	3	5	25	Very High Risk
Adjusting gears /chains /sprockets	Pinch/crush injuries	P	Use appropriate tools. Keep fingers away from moving parts.	3	2	3	18	Possible
Assembling the system	Dropping components causing injury or damage	P/E	Use a crane to lift heavy components. Secure components during assembly.	3	2	3	18	Possible
Electrical wiring	Electric shock, fire hazard	P/E	Follow wiring guidelines. Use proper connectors and insulation.	3	2	4	24	Very High Risk
System calibration	Equipment damage due to incorrect setup	E	Follow step-by-step calibration procedures. Verify settings with a supervisor.	2	2	3	12	Possible
Testing the system	Unintended movement leading to injuries or damage	P/E	Ensure emergency stop is functional. Keep clear of moving parts during tests.	3	3	3	27	Very High Risk
Maintenance & repair	Electric shock, mechanical injuries	P	Disconnect power before servicing. Follow lockout/tagout procedures.	3	2	4	24	Very High Risk

Key:

- **Likelihood (L):** Rated from 1 to 5, with 1 being very unlikely and 5 being very likely.
- **Exposure (E):** Rated from 1 to 5, with 1 being rare exposure and 5 being constant exposure.
- **Consequence (C):** Rated from 1 to 5, with 1 being minor consequences and 5 being severe consequences.

Risk Classification:

- **Acceptable:** Risk score ≤ 10
- **Possible:** 10 < Risk score ≤ 20
- **Very High Risk:** Risk score > 20

Testing

Overview of Testing Activities

This section outlines the procedures for testing the system in order to make sure that it is safe for use.

Equipment

- Weights (sandbags of 20kg)
- Weight attachment system
- Safety mattresses
- Safety gear (Helmet, gloves, safety shoes)

Detailed Breakdown of tests

Safety Measures for all Tests: Set up a safety perimeter. Wear safety helmets and closed shoes. Clear space around the structure for a quick exit if anything goes wrong. An external person must be ready to push the E Stop at any given time and should be clear of the structure.

Phase 1: Static Load Testing

1. **Inclined Panel Load Test**
   - **Procedure:** Mount wooden panel to test stand through chain hole mounting points at a 45-degree incline. Hang sandbags, one by one, to the middle of the panel until the weight of a person is reached (80kg)
   - **Observation Points:** Check for any immediate signs of fracture and listen for any cracking sounds.

2. **Inclined Static System Load Test**
   - **Procedure:** The wall is inclined to 45 degrees. Gradually apply a static load to the wall equivalent to the weight of an average person (approximately 80 kg).
   - **Observation Points:** Check for any immediate signs of tipping or structural deformation.

Phase 2: Dynamic Load Testing with Weights

1. **Tilting Mechanism no load test**
   - **Procedure:** Test full tilting functionality by sending tilt commands to the system for extreme angles.
   - **Observation Points:** Make sure system stops and does not crash at extreme angles. Use images or protractor to verify angle of inclination.

2. **Rotating surface light load test**
   - **Procedure:** Test rotating surface functionality by attaching a light load to a panel near the top of the rotating surface. The load should be just enough to move the

surface. Start with slowest speed setting for the first test. Repeat test, incrementing speed until fastest desired level is reached.
- **Observation Points:** Verify through video or stopwatch and measuring tape that each speed level matches the input.

3. **Rotating surface full load test**
   - **Procedure:** Repeat test 2 with an 80kg weight added to the panel.
   - **Observation Points:** Verify through video or stopwatch and measuring tape that each speed level matches the input. Watch for any signs of malfunction or failure.

Phase 3: User Testing

1. **Rotating Mechanism Slight Incline User Test**
   - **Procedure:** The incline of the surface should be set to a few degrees overhanging for the safety of the user. The speed should be set to low, and the user slowly applies weight to the wall until it starts to rotate. Once the user is happy with the functioning of the mechanisms and structure, full weight can be applied to the wall.
   - **Observation Points:** Check for any immediate signs of tipping or structural deformation. Any signs of system failure should result in the user immediately letting go of the climbing holds and moving away from the system. Verify through video or stopwatch and measuring tape that each speed level matches the input.

2. **Rotating Mechanism Full Incline User Test**
   - **Procedure:** Repeat test 3.1 with the wall set to its maximum incline.
   - **Observation Points:** As seen in test 3.1

Testing Risks Summarized

The table below summarizes the risks faced during testing, as well as outlining mitigating steps for each risk.

Activity	Risk	Risk Type	Mitigating Steps
Static Load Testing	Structural failure or tipping	P	Ensure all personnel are clear of the wall during loading. Wear safety helmets and gloves.
Dynamic Load Testing with Weights	System malfunction or crashing at extreme angles	P/E	Be ready to push the E Stop button in case of a system malfunction. Ensure all personnel wear safety gear.
Tilting Mechanism no load test	System malfunction	P/E	Be ready to push the E Stop button. Ensure all personnel wear safety gear.
Rotating surface light load test	System malfunction	P/E	Be ready to push the E Stop button. Ensure all personnel wear safety gear.
Tilting Mechanism full load test	System malfunction	P/E	Be ready to push the E Stop button. Ensure all personnel wear safety gear.

Rotating surface full load test	System malfunction	P/E	Be ready to push the E Stop button. Ensure all personnel wear safety gear.
Static User Test	Tipping or structural deformation	P	Wear safety helmets and gloves. Clear space around the structure for a quick exit.
Tilting Mechanism User Test	Tipping or structural deformation	P/E	An external person must be ready to push the E Stop. Wear safety helmets and gloves.
Rotating Mechanism User Test	Tipping or structural deformation	P/E	An external person must be ready to push the E Stop. Wear safety helmets and gloves.

*P – personal, E – equipment

Shutdown Procedure

1. Let any persons using the wall know that it is to be shut down so they may finish use and move away.
2. Turn off motor driver power.
3. Turn off power at wall and remove the plug.

General Laboratory Safety

The following general laboratory safety instructions are applicable:

- No afterhours testing may be performed without the necessary permissions.
- Closed shoes must be worn at all times.
- Emergency equipment must be located and easily accessible.
- Students may not work alone in the laboratory when performing operational testing.
- Emergency exits must be known. The nearest exits applicable to the setup are highlighted with red circles in Appendix A.
- Loose clothing may not be worn. Loose hair must be tied up.
- Good housekeeping practices should be maintained during testing. The lab should be completely clean, including all equipment stored away, after testing. Refer to the General Housekeeping section for particulars regarding practices to be followed for this specific setup.
- No food or drink is permitted in the laboratory.
- Safety report must be visible and accessible during testing.
- No equipment or test may be left unattended.

Anticipated Interactions with other Laboratory Users
Determine unsafe zones and create a safe perimeter around the structure with danger tape. Print a sign that reads: “DANGER, KEEP OUT!”

General Housekeeping

1. Maintain Clean Work Areas:

- Regularly sweep and clean floors.
- Keep workstations tidy and organized.
- Dispose of waste materials properly.

2. Proper Tool Storage:

- Store tools and equipment in designated areas.
- Ensure tools are returned to their proper place after use.
- Conduct regular inspections for damaged tools and repair or replace as needed.

3. Clear Walkways:

- Ensure all walkways are free of obstacles and debris.
- Mark hazardous areas clearly.
- Remove spills immediately to prevent slips and falls.

Fire Safety

The fire risk is low for this project, however in the unlikely event of a fire in the laboratory caused by electrical/other means:

1. Assess the type and magnitude of the fire.
2. Use the fire extinguisher on the fire if it is safe to do so.
3. Activate fire alarm if fire is deemed out of control.
4. Disconnect machinery from power if it is safe to do so.
5. Exit the laboratory, closing doors behind you
6. Make way to assembly point

Fire elsewhere in the building:

1. Perform shutdown procedures.
2. Exit the laboratory, closing door behind you.
3. Make way carefully to assembly point.

Disciplinary Actions

Failure to comply with any of the aforementioned safety regulations or procedures will result in disciplinary action. Students will be issued an initial warning: after three warnings, the Laboratory access is revoked for a month.

Appendix A: Emergency Evacuation Plans

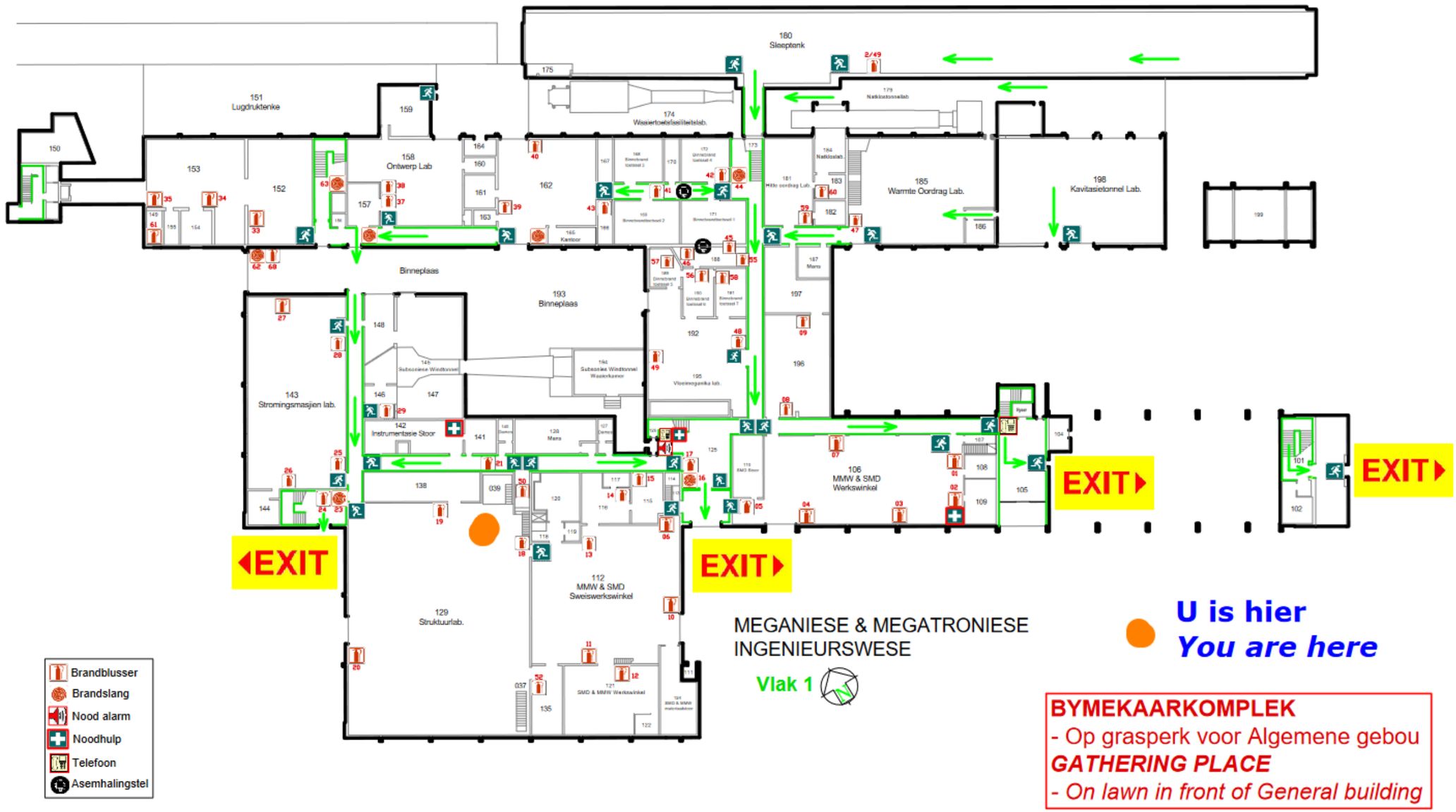

Figure 2: Evacuation routes for Laboratory 129