Canadian AgriSafety Applied Science Program

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Designing Rollover Protective Structures (ROPS)

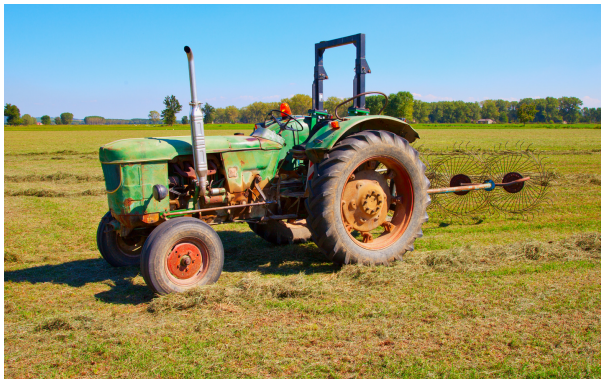
Within the agricultural community, there is a need for improved safety solutions for machinery and in particular tractors. Rollover Protective Structures or ROPS are a proven method to reduce the risk of serious injury and death in the event of a tractor rollover; however, there are many older model tractors currently in use on Canadian farms that do not have ROPS installed. One of the known barriers to installing ROPS is the cost as pre-fabricated ROPS often exceed the overall value of older tractors.

Previously, under the 2014 – 2018 Canadian AgriSafety Applied Research Program, a ROPS intervention project was investigated and developed. The intervention model included the development of engineered ROPS fabrication blueprints which were then provided to farmers for local fabrication with the goal of offering a low-cost option for building and installing ROPS on older model tractors that are still in use on Canadian farms.

Design Considerations

There are several factors that require consideration when designing a ROPS, including identifying potential tractor accident scenarios and the subsequent forces resulting from the accident which are often complex. The Canadian Standards Association (CSA) B352 Rollover Protective Structures (ROPS) – General Canadian Requirements Standard is the main ROPS development standard in Canada. The ROPS Project has developed its designs in accordance with the Canadian Standards Association (CSA) B352 standard including dimensional requirements, stresses, plastic deflection, and energy absorption parameters.

An additional challenge to designing ROPS is that the CSA standard defines a clearance zone based on tractor-seat occupancy by a large seated male. ROPS must be designed so that structure is not within the clearance zone and cannot enter that zone as it deflects or deforms during the ROPS structural integrity tests. Also, for 2-post rollbar style ROPS, the design must ensure the operator will not contact the ground.



Designing ROPS for use in Canada also poses further challenges due to the need to withstand cold weather. Certain type of materials can fail prematurely in cold temperatures through brittle fractures. To effectively test ROPS for use in Canada, testing is conducted at -18 Celsius or using alternate lab tests that ensure the material is not subject to brittle fracture under cold conditions using the Charpy V-notch test.

Testing ROPS

The test requirements for ROPS are intended to provide protection for the operator wearing a seatbelt under at least the following conditions:

- 360 degree roll about the machine longitudinal axis on a hard clay surface of a 30 degree maximum slope at forward speeds up to 16 km/hr without losing contact with the slope
- 180 degree rear or frontal overturn on a hard dry surface without losing contact with the surface

In order to achieve an effective design, ROPS must be designed to deform like the front end of a car in order to minimize the impact of the rollover. When ROPS are designed to 'bend' but not break the force of impact on the tractor and operator is reduced. ROPS testing consists of 3 parts:

1. Force applied to the side of the ROPS
2. Force applied to the rear of the ROPS
3. Downward crushing force on the ROPS

There are two methods of applying the forces to test ROPS. The traditional dynamic method uses a 2,000 kg steel block swung from a pendulum which then impacts the ROPS. The more common static method utilizes hydraulic cylinders or the equivalent which can apply higher, more consistent and repeatable forces to the ROPS.

Finite Element Analysis (FEA) design software allows engineers designing ROPS to model different designs as the material transitions from elastic to plastic deformation. Deflections of the ROPS can be simulated allowing engineers to determine the energy absorption while forces are being applied. However, physical testing of a final design remains the gold standard to ensure that the designed ROPS meets CSA Standards. It is important to note that ROPS are designed to be used in combination with seatbelts. The CSA B352 Standard refers to the ISO Standards that describe the requirements for seatbelts to keep the operator within the safe clearance zone in the event of a rollover.

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