Box 8.2 *Recent laboratory research on falling aprons*

A pilot study was performed on the behaviour of falling aprons by testing small-scale models in the flume (van der Hoeven, 2002). The falling aprons tested were designed for the guide banks of the Jamuna Bridge project (see Box 8.1). Figure 8.28 shows the expected behaviour of the falling apron in prototype and in the laboratory.

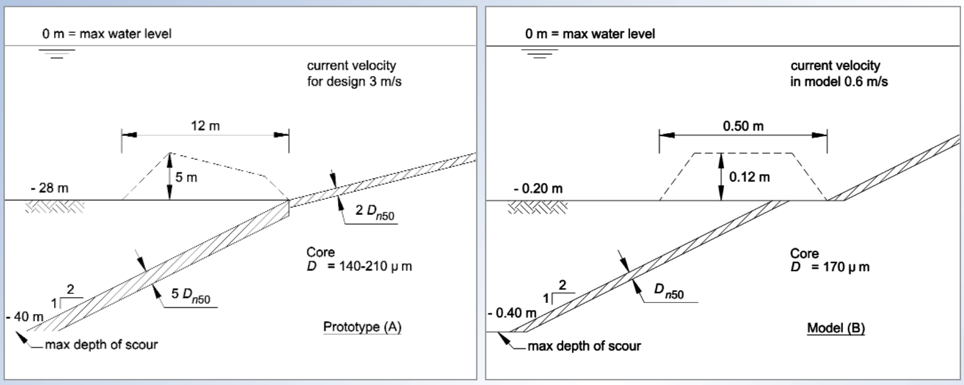

Figure 8.28 *Expected behaviour in prototype (A) and observed behaviour (B) in laboratory test*

The purpose of the laboratory tests was to:

1. Obtain insight into the falling process and the successive phases.
2. Determine whether different configurations influence the final slope ie is special care during dumping necessary.
3. Determine how an apron with insufficient armourstone should be re-strengthened.
4. Determine whether the use of a falling apron can provide a durable protection against scour.

When designing a falling apron, the following aspects should be considered. As the apron will finally be formed in the model, it will be of a single armourstone layer on a steep slope 1:2. It should first of all be checked whether the armourstone size (D_{n50} = 0.20 m in the prototype) is large enough on this steep slope. A verification of the slope stability (see Box 8.3) is done, not using the revetment angle but the apron slope angle, α = 26.5°(1:2 slope). Considering this apron angle and a value of ϕ = 40° for the angle of repose, the relevant slope reduction factor can be assessed using Equation 5.116 (Section 5.2.1.3): k_{sl} = 0.7. The appropriate size of the armourstone required for stability against current velocities up to U = 3 m/s can be evaluated using the Pylarczyk formula, Equation 5.119 (Section 5.2.3). Values used for the various factors and parameters are: mobility parameter, ψ = 0.035; relative buoyant density of the stones, Δ = 1.65; stability factor, Φ_{sc} = 0.75; velocity profile factor (for h = 30 m), k_h = 0.68; and turbulence factor, k_t^2 = 1.0 (ie normal turbulence level). The armourstone size required is: D_{n50} = 0.19 m, with a corresponding mass of M_{50} = 20 kg. An armourstone grading of 5-40 kg (D_{n50} = 0.22 m) is appropriate. A wide grading is intentionally selected to limit loss of fines from the underlying material, since a granular filter layer or geotextile under the apron is missing. An expected scour of 6 m implies a minimum volume of armourstone in the apron of $0.22 \times 6.0 \times \sqrt{5}$ = 2.96 m³ per linear metre of revetment. The apron should be placed at a water depth of 15 m, necessitating high placement tolerances. The behaviour cannot be predicted in detail when a volume of 6 m³ per linear metre of revetment is placed.

8.2.7.5 *Flexible open revetment*

The terminology *open revetment* is used to distinguish loose stones from fully or partly grouted armourstone. A practical design procedure for a flexible open revetment is presented here. It often takes place in successive steps described as follows:

Step 1: Assessment of the **erosion resistance of the non-protected** soil and determination of the area of slope to protect.

Step 2: **Sizing the cover layer** for stability against hydraulic loading, including wave attack above water and current attack under water.

Step 3: **Selection of the material** including size and durability.

Step 4: Design of the **filter system** and the **sub-layer**.

Step 5: Design of the **toe protection** and any **transitions**.