Rain-Induced Shadows

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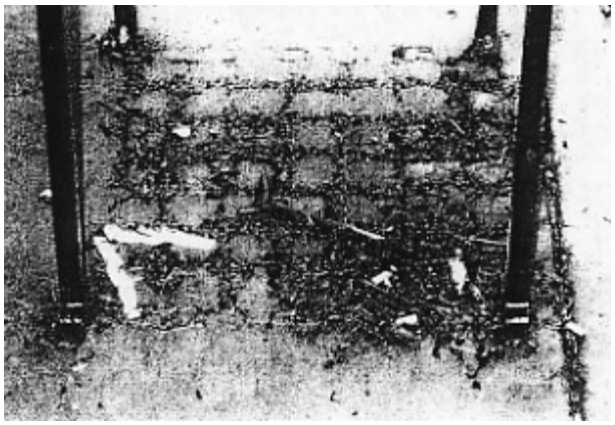
The Physics Teacher, Vol 4, November, 2006

Several times a week I walk by a metal chair that is fastened to a flat concrete slab at an outdoor bus stop here in Boulder. One day I noticed on the concrete a nice shadow image of the woven metal seat of the chair (Fig. 1). The seat and back of the chair are formed from 3.8-cm wide strips of metal spaced 3.8 cm apart. The seat is about 39 cm above the concrete. Here's how I think this shadow image was produced.

Tentative Explanation

Distributed initially on the concrete was a random accumulation of pieces of grass, twigs, leaf fragments. and other yard debris. A brief light rain fell on a quiet day with no wind. The rain drops passing vertically down through the 3.8-cm-square openings struck the concrete and splashed into fragments, which have large components of velocity in horizontal directions. These fragments carried nearby small pieces of debris horizontally with client. The motion of the many particles of debris was probably somewhat similar to a two-dimensional random walk. When a particle of debris was carried into the rain "shadow" where no drops were filling, their random motion ceased. So after a tithe, all of the debris particles were deposited in the "shadow" of the metal strips, leaving the pattern that is observed.



More Details

In the chair, the metal strips and the gaps between them are of the same width - 3.8cm. On the concrete, the debris "shadows" of the strips have a width that is less than the width of the metal strip of the seat of the chair. This is as one would expect because in splashing, the raindrops give debris particles horizontal velocities that would carry them some distance into the geometrical "shadow," making the "shadow" narrower than the metal strip. This is seen in the close-up of Fig. 2. It is necessary that the rain not be so intense that it generates a strong stream of water flowing over the concrete; this would wash away the pattern.

The concrete does slope slightly down from the back to the front of the chair (downhill toward the camera in Fig. 1), and the resulting washing probably modified the pattern. There must have been some flow of water over the concrete, which moved debris that was then partially trapped by the large stick under the right back corner of the chair. The "shadows" from the front of the chair are mostly gone, possibly having been washed away.

At the front of the chair, the horizontal flat metal straps are welded to a horizontal cylindrical tube. The rain falling on this tube flows around the outside and to the bottom of the tube where it forms drops in a line along the lowest part of the bottom of the tube. This is above the center line of the "shadow." So the "shadow" created by the tube is modified by the drops falling from the bottom of the tube and striking the debris in the middle of the shadow. This moves debris away from the middle of the shadow and converts the one line of the shadow into two. Only traces of the two shadows from the front tube of the chair can be seen here.

Conclusion

Interesting physical phenomena abound all around us. They challenge us to observe and then to postulate plausible physical processes that will explain the phenomena.

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