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A study on air accumulation in high-lift siphon hoses under the influence of air dissolution and diffusion

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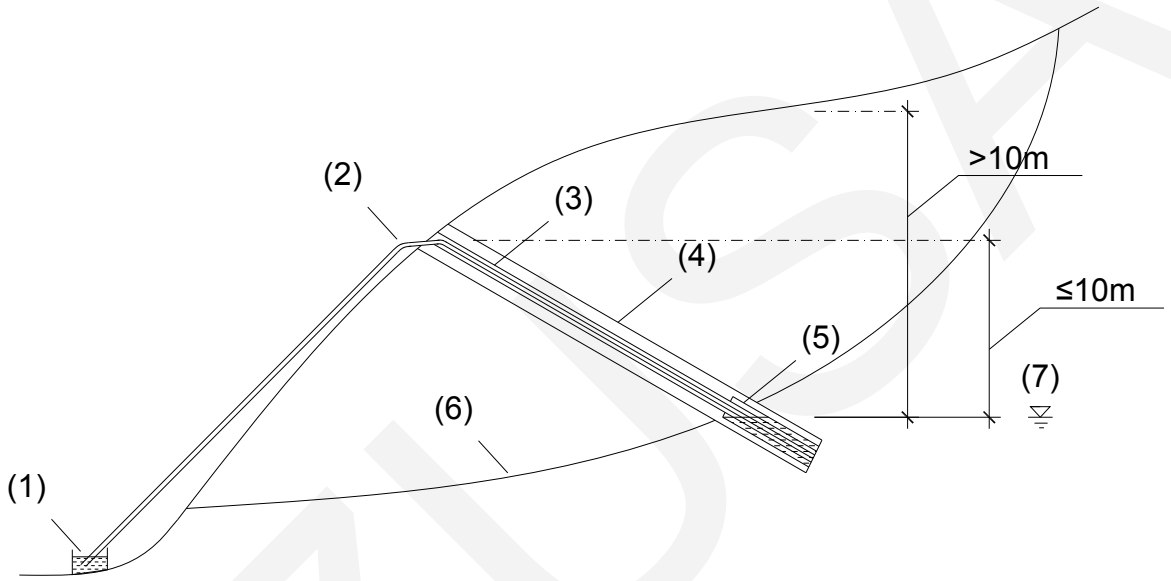
Key words: slope, siphon drainage, motionless flow during dry season, air accumulation, air diffusion, temperature

Inclined high-lift siphon system in slope drain



1: outlet; 2: siphon drain (consist of three PU hoses);3: pervious pipe; 4: inclined drilling; 5: standpipe; 6: potential sliding surface; 7: controlling groundwater level

Fig. 1 Inclined high-lift siphon system in slope drain

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Air accumulation in long-term motionless siphon hoses

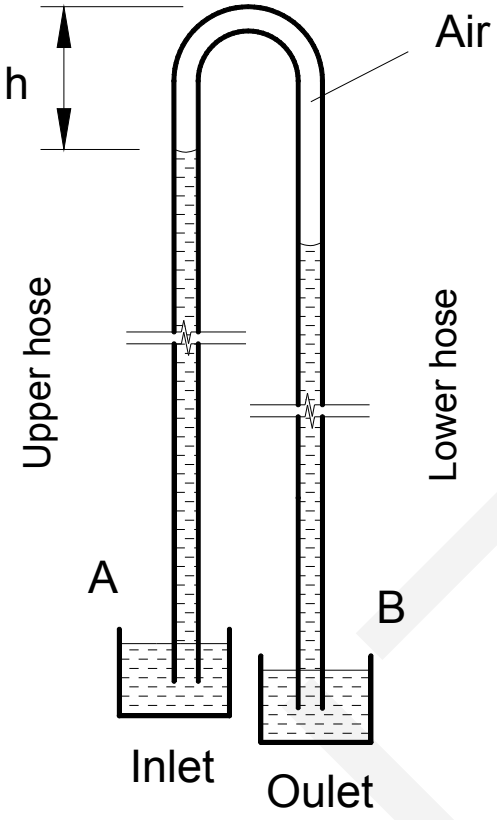

Fig. 2 Schematic diagram of siphon system

Irregular rainfall may result in long-term dry seasons and motionless siphon flow. Since the static water in siphon hoses can no longer discharge air out of the hoses shown in Fig. 3a, the excessive air will be released and accumulate in an air column at the top of the siphon hoses as shown in Fig.2.

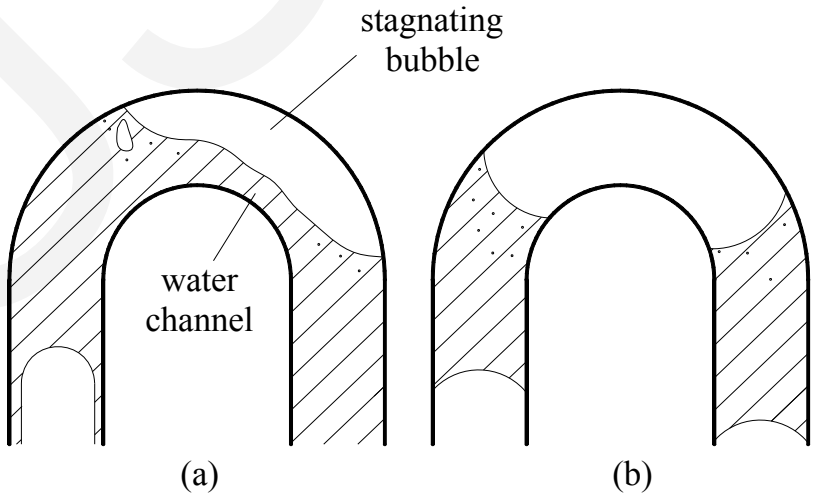

Fig. 3 Different flow patterns at the top of large and small diameter hoses

(a) Flow pattern at large diameter hose;
(b) Flow pattern at small diameter hose.

Three factors on air accumulation

Original air release

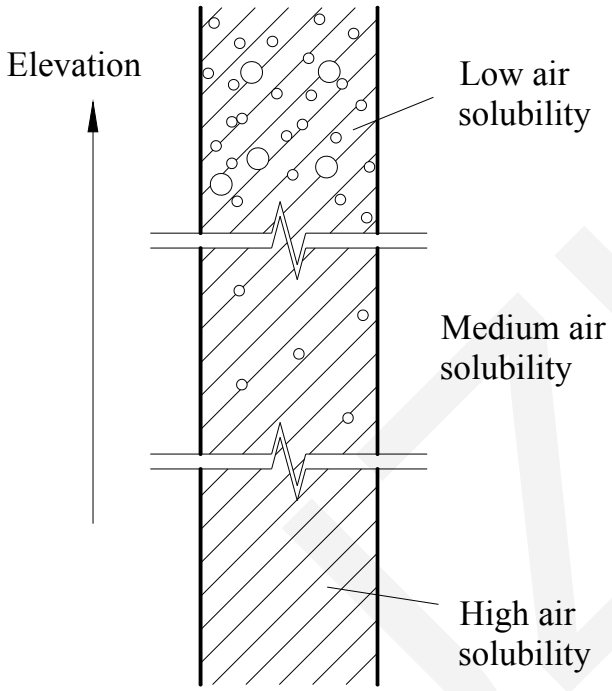

Fig. 4 Original air release in high-lift siphon

Air Diffusion

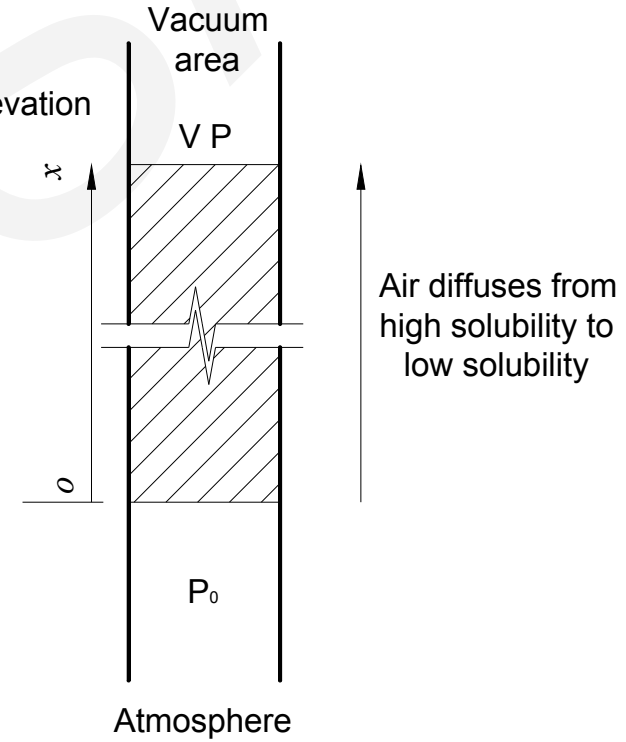

Fig. 5 Air diffusion in high-lift siphon

Three factors on air accumulation

Air release due to temperature

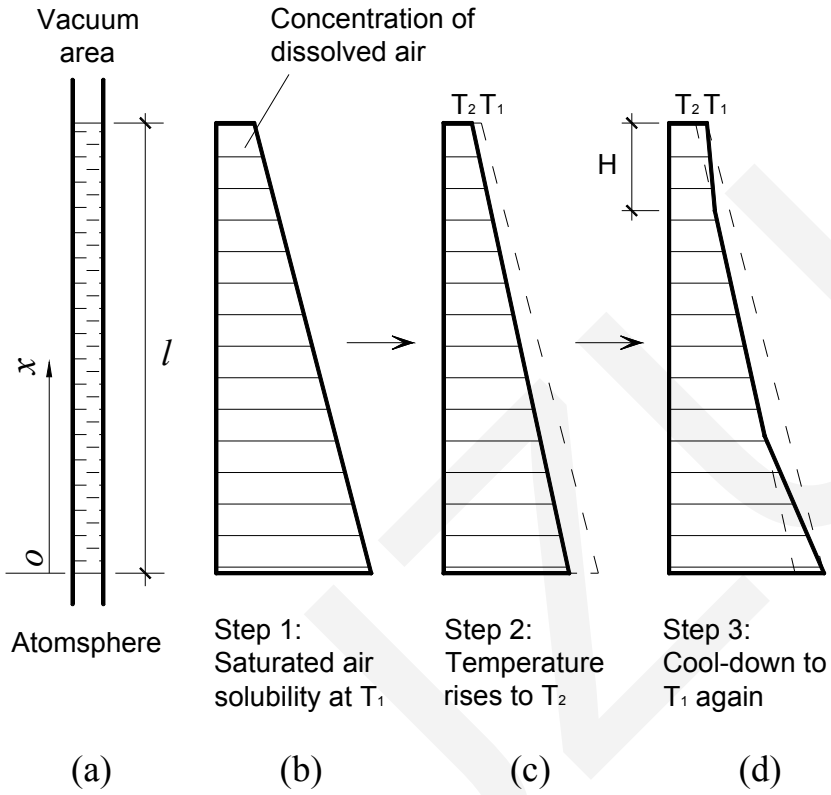

Fig. 6 air dissolution variation with changing temperature

In reality, the released air will accumulate at the top of the siphon hose when the temperature increases. However if the temperature falls air diffusion from top to bottom will seldom happen due to the concentration gradient and so air can only be supplied from the outside. Thus, air release induced by temperature increase will always result in air accumulation.

As for 10m-long siphon hoses, several meters along the central part of the siphon hoses are rarely affected by air re-dissolution (see Fig. 6d).

Conclusions

- Pressure decrease in high-lift siphon hoses will cause supersaturated air release and induce a maximum 1.5m long air column at the top of the siphon hose;
- Temperature increase can induce a maximum 0.55m long air column. On the other hand, air re-dissolution and supplement from temperature decrease can only affect a less than 1.1m length of water column, which is negligible in a high-lift siphon
- Air diffusion from water will lead to a less than 0.01mm increment of air column at the top per day, which is considered to be negligible compared with that induced by air release due to pressure and temperature variations
- Results in this study indicate that high-lift siphon drainage can also be effectively used in districts where it seldom rains. In siphon drainage design, at least 2.05m long space to the safety level should be left for underground water rise, or just keeping the outlet 4.1m lower than the inlet can guarantee that the released air will be gathered in the descending hoses