

MRGHOLQURZLQ8EDQ)RUPDDLQVW6DQG Accumulation FDVH6W&6DOWDWRQLQWKH7RZQRI7LPLPRQLQ Southern Algeria)

¹ MTR ² DMH ³ KH

3RQWHERW...
3RQWHERW...
3RQWHERW...

Received 10.01.2015; Accepted 03.14.2016

ABSTRACT: QRESUHVHQWUHVHDFKZHIFXRQWKHPRGHOLQRIDLURZUHODWHGWRQDWKDOGLVDVWHU...
reduce as much as possible stagnation of sand in the building area (streets, alleys, etc.). The urban form design will be
GLVFXVVHG WKURXJKWKH VLPXODWLRQRIDLUZEXVLQJ&RPSXWDWLRQDO)OXLG'QDPLFV&),QWHUPRIVLPXODWLRQ
ZH VLPXODWHG WKHDLURZEHKDYLRU ZKLFK LV UHVSQVLEOHRI VDQG VWDJQDWLRQLQVRPHVSHFLFRQJXUDWLRQV\$W
JURXQGZDVFKRVHQZLWKDJVWFRQJXUDWLRQZKLFKZDVIDULHGWRWHVWDFKWLPHDFXUUHQWDLURZEHKDYLRULQV
FRQJXUDWLRQ7KLVRGHOLQLVPDGHRSRVLEOHIROORZLQJDQSSURSULDWHVWXUEXOHQFHPRGHO,QWKLVVWVGDFRUUHO
was made between urban wind speed and morphological parameters such as aspect ratio, building geometry and
building density. According to our theoretical references, this correlation shows that urban wind speed can help reduce
sand stagnation with proper values of these parameters. Therefore, through the urban form study we can promote wind
speed and blow away the accumulated sand till the urban limits.

.HZRUGV &RPSXWDWLRQDO)OXLG'QDPLFV&)6DQGDFFXPXODWLRQ6DOWDWRQLQ8UEDQIRUP8UEDQ
JHRPHWU\DNHHIIHFV

INTRODUCTION

Timimoun is a town and commune, and the capital of Timimoun District, in Adrar Province, south-central Algeria. The town of Timimoun lies at an altitude of around 288 metres (945 ft) in the Gourara region of northern Adrar Province (Bisson, 1957). It is located on southeast of an oasis, which supports the source of water for the town. A sebkha (salt lake) lies further to its northwest, while the plateau of Tademaït lies to the southeast. (Fig.1)

Like the arid regions of the world, Timimoun region now faces the thorny problem of sand accumulation Fig.2. This phenomenon is mainly caused by the severity of arid climatic conditions and the wrong choice sometimes of human settlements inside Erg. In fact, the wind is the key factor that is responsible for this phenomenon. The consequences on society and economy are serious: decline in agricultural production,

migration, unemployment and lack of basic services; housing, health, education ...etc. (Kara, 2008)

Fig. 1: Town of Timimoun. (Bisson, 1957)

Timimoun has a hot desert climate BWh (Köppen climate FODVVLFDWLRQZLWKH[WUHPHOKRWVXPPHUV DQG PLOGZLQWHU and very little precipitation throughout the year. The silting

*Corresponding Author EmailGMDPHOPHVWRXO#DKRRIU



Fig. 2: human settlements inside Erg, town of Timimoun. 2012

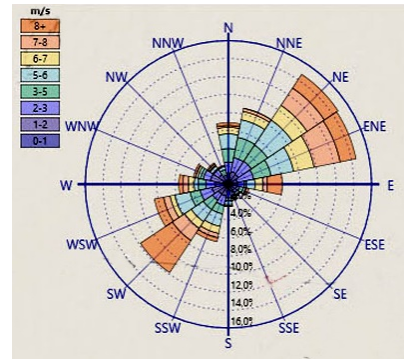


Fig. 3: Wind rose for the town of Timimoun (1995-2010). ONM-Dar-El-Beida, Algiers

is quite recurrent in the region Timimoun. This is due to the fact that this region is exposed to strong winds that can reach a speed of 8m/s in the northeast and southwest (Mestoul, 2011) Fig.3.

7KHREMFWLYHRIWKLUVUHVDUFLKLVWRGHQHDQXUHQQRILRYKDW
 FDQJKWDJDLQVWVLOWLQJ7KLVLVDQXUEDQIRUPWKDWLVDEOHW
 SUHVHQWDVSHFLFLPSDFWRQWKHPRYHPHQWRIDORFDOZLQJ
 7KLVVSHFLFLPSDFWLVFRUHVSRQGLQWRDQDHURGODPLF

mechanism to facilitate the passing of moving sand. The ventilation mechanism will be evaluated by the study of urban form parameters (e.g., aspect ratio H/D, E/D). These physical parameters are associated with a wind velocity of the order of 2 to 4m/s (saltation threshold).

MATERIELS AND METHODS

EYHQWKHKGQDWKHRIZLQGWKHPRVWFULWLFQIDFWRDQQRORIKHDLURZDURXQGWKLVERGPRYHPHQW
 FRWUROOLQWKHDLURZDWWKHKEDQVFDQHLVWKLHVSDFHURPHVJL

All spaces between buildings, both horizontal spacing, the relationship of the building with its height, called the urban SURQHWKDWGHWHUPLQHVWKHOHYHORIVKHOWHURHHSRYXUHWBZLQJ

To understand the behavior of the wind within the urban form we made use of Computational Fluid Dynamics (CFD). The simulation will be performed with the code Fluent in which we chose the turbulence model (k-standard). This model is the PRVWFRPPRQXVHGWRVLPXODWHWKHPHQWRZFKDUDFV
 LQWXUEXOHQWRZFRQGLWLRQV
 7KURXJKWKH&VLPXODWLRQZHZLQWUWRGHQHWKH
 ratio (H/D) and (E/D) of urban form, which is capable to maintain a wind velocity the order of 2 to 4m/s in the built environment. This velocity will be able to blow away the sand grains with a diameter of 50 micrometer (saltation mode) from the urban area.

RESULTS AND DISCUSSION

ENVHRI6LPSOH5RZRI9ROKHV

Based on the theories of (Bouvet, 2003) and (Duchemin, 1958), we chose a series of volumes that have the same dimensions

GHQHGHLQWKH7DEOHDQGLWLVRXQGDVWKHRQHZLWKWKHO

GHQHGHLQWKH7DEOHDQGLWLVRXQGDVWKHRQHZLWKWKHO
 GHQHGHLQWKH7DEOHDQGLWLVRXQGDVWKHRQHZLWKWKHO
 GHQHGHLQWKH7DEOHDQGLWLVRXQGDVWKHRQHZLWKWKHO
 GHQHGHLQWKH7DEOHDQGLWLVRXQGDVWKHRQHZLWKWKHO

Table 1: Characteristics of the tested model (type A).

Name of model	Height (H) P@	Length (L) P@	Distance between YROXPHV P@	Ratio H/L	Ratio P/P
Type (A)	5	10	15	0,5	0,66

shown in Fig.3. The results of simulation seems to support the

hypothesis of (Bouvet, 2003) following which the upstream accumulation with body is not important. This results in the movement of side wind is easily dissipated through the opening

RIWKH HOG EHWZHHQWKHPDUNHG YROXPHV 7KLV GLVVDQFH
 is about 3H, and the ratio of building length to the building
 VHSUDWLRQ/LVDSSURLPDWHO7DEOH

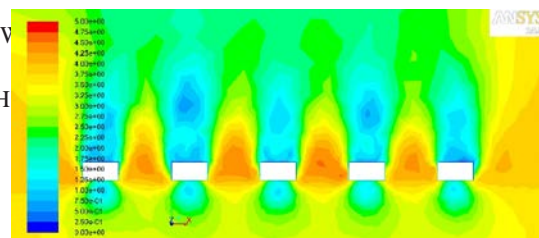


Fig. 4: graduating speed around volumes type B.

However, at the upstream/downstream side, the wind tends to decelerate because of the wake effect, which occurs at the upstream/downstream of the volume. This wake effect is VKRZQLQ)LJ,Q WKL V JXUH XVLQJD UHSUHVHQDWLRLQ DLU. From the arrows we see that a wake effect is created in the zone 1 due to the buffering of the air against the edge of the volume (A). Then in the zone 2, air tends to turn back in zone 2 before hitting against the leeward side (zone 3). Therefore, zone 1 and 3 will be necessarily accumulation areas once the air velocity is zero. It means that in these areas the air can be discharged and can give rise to sand accumulation, called sediment.

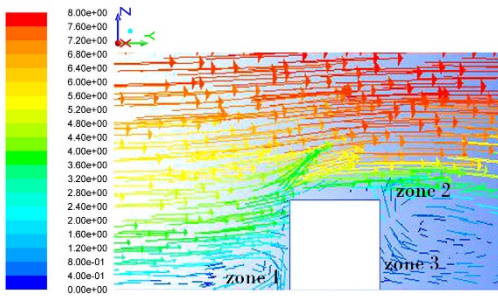
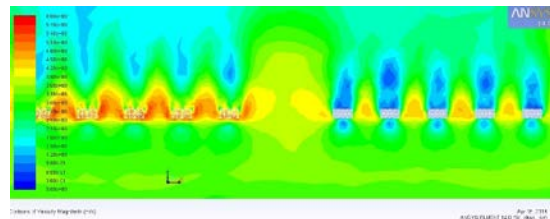


Fig. 5: graduating air velocity around a simple volume type A on the ground.

The Fig. 7 shows from a plan view the result of comparison between a row resting on the ground and the elevated volumes. We found that the volumes on stilts have a wind velocity much higher (sometimes up to 6m/s) than those placed on the ground, near the ground behind the volume as well as to between the rows. This is explained by the fact that the pressure is released under the raised volume and later transformed into kinetic energy, which could remove the wake interference and reinforce the initial speed of 3m/s (green) to 6m/s (red).



(A) (left) and volumes placed on the ground (right)

3 (wake effect) to avoid sand accumulation in zone 4. This means to take some action to remove the wake effect in the GRZQVWUHD PDLURZRIWKHYROXPH. For this, we conducted a built-on-stilts volume type (A) to release the compressed air in the pressure zone of the wind, and transform the potential wind energy into a kinetic energy. The DLURZLOOKDYHWRSDV V XQGHUWKHYROXPHDQGLVDSDDQZQMHWRIRXU IXWXUH SURWRW\$H:HGQH KHUH:DV effect in zone 2. Zone 3 will no longer be an accumulation zone. In the simulation, we took the same series of volume type \$GHQHGDERYHLQWKH7DEDQGLQWKL V WLPHZHUDLVHGWKHPD height of 3m from the ground. (Fig. 6)

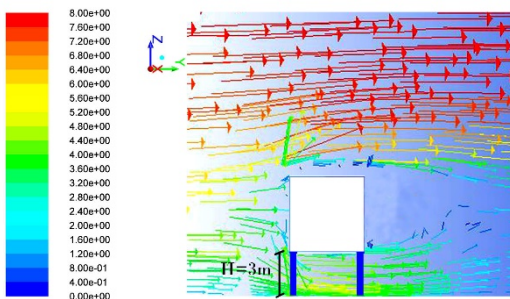


Fig. 6: graduating air velocity around raised volume type (A), h = 3m.

&DVHRID6HYHUDO5RZVRI9ROXPHV8UEDQRUP

In the former experiment, the ratio between the length of EXLOGLQJDQGWKHSDFLQJEHWZHHQWZREXLOGLQJVLV. In the second part of our research, we will address the issue of DLURZEHKDYLRUZLWKVHYHUDOURZVRIYROXPHV\$H\$2XU DLPLVWRQG UHODWLRQZLWKWKHSDFLQJEHWZHHQWKHURZV. In addition, the ratio H/D and E/D play an important role on the VDSDDQZQMHWRIRXU IXWXUH SURWRW\$H:HGQH KHUH:DV the building width, H the height, L the length, D the spacing between two adjacent rows and E the urban length. (Fig. 8)

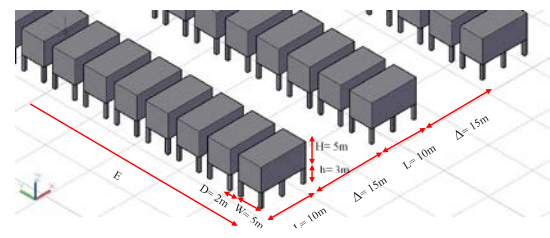
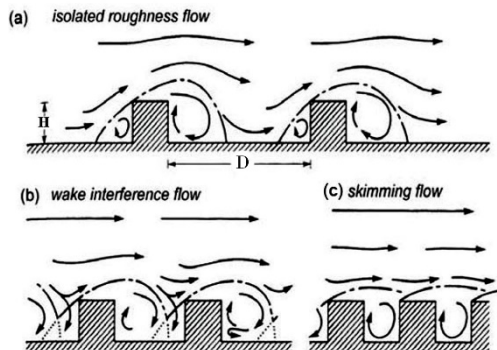


Fig. 8: urban form model consists a several rows of type (A) volumes.

The research led by (Oke, 1988) count among the most detailed ZRUNRQWKHLPSDFWRIDQHWHQVLYHXUEDQDUHDRQDLURZ2NH

studied the impacts of the urban density, with varying ratio of H/D or equal to one (Fig. 9). That is to say, smaller driven by the dominant wind above the roof (Nakamura & Oke 1988, Santamouris et al., 1999). It is strongly affected by the over arrays of buildings is approximately normal to the street axis, three regimes can take place depending on the aspect ratio (H/D) and building ratio (L/D). These regimes are respectively

7R KDYHD VNLPLQJ RZ UHTXLUHV WKDW WKH UDWLR +' KDV D DUUDIDS'WLJKWEXLOGLQJVSUHVHQWVDRZPRUHVNLPLQJ 7KHUHIRUHWKHDLURZSDVVHVRYHUWKHURRIZLWKRXLQWH In this third part of our research, we focused on the study of the behavior of wind within an urban form that consists of several series of volumes with dimensions shown in Table 2.



ratio and building geometry (Hosker, 1985).

The transition from one regime to another occurs at some special values of H/D (Hussein & Lee 1980) and L/D (Hosker, 1985). The spacing between the upwind buildings is a factor interfere regime. However, when the buildings are long, the front spacing shows little impact. In the same way, Hosker the function between the canyon ratio (H/D) and the building geometry (L/H). However, the role of canyon ratio (H/D) is dominant, while (L/H) is inferior. (Fig. 10)

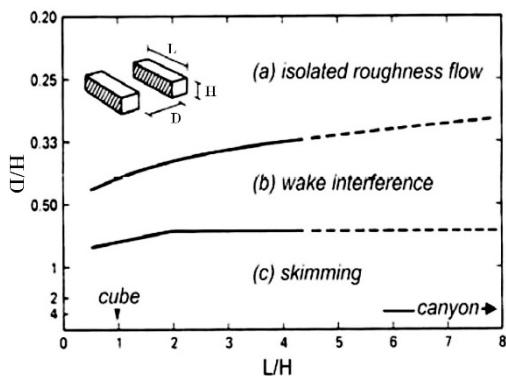


Table 2: Characteristics of prototypes of studied urban forms.

Models	9ROXPHV+HLJKW+P@	9ROXPH:LGWK'P@	Spacing between volumes P@	Spacing between rows P@	Number of rows	Elevation from the ground KP@
(1)	5	10	15	2	15	4
(2)	5	10	15	2	15	3
(3)	5	10	15	2	15	2

Rows of volumes are separated with a small distance (D=2m) avoid the interference between the buildings that can produced accumulation of sand between buildings.

The urban form we used for modelling is all composed of volumes type A, which is raised above the ground (h=2, 3 and modeled this urban form in Fluent to see its interaction with DQ DLURZ RI PV JLYHQ 7LPLPRXQV ZHDWKHU 7KH LQSXW YHORFLWL V GHQHGDFFRUGLQJ WR WKH XVHUGHQHGIXQFWLR XGIKLQ)OXHQW7KHURXJKQHV VFRHIFLHQWLQWKHSRZHUODZ ZLQG SURQ ZDV FKR VHQ DQG WXUEXOHQFH PRGHO ZH KDYH FKR VHQ . VWDQGDUG ZDV FKR VHQ IRULWV JHQHUDO VDWLVLC performance.

$$U_z = U_o * (Z/ Z_o)^a \dots\dots\dots(1)$$

$$U_o = 8\text{m/s}, a=0.3, Z_o=10\text{m},$$

We varied the elevation height of the stilts of the volume type A to see if there is an improvement in the speed of the air passing through the urban form under its raised volume. The goal is to test the impact of elevation from the ground on the wind speed under the raised buildings. In addition, we try to observe which urban length (E) can keep the speed to a threshold of saltation either (2 to 4.5 m/s). According to the literature (Bagnold, 1941; Pethick, 1984; Anderson & Haff 1991;Kok & Renno

2009), we suppose that this velocity would still be able to put in motion the accumulated sand grains under the raised buildings remove them.

)LJ LOOXVWUDWHVSHUIHFWO\WKHGLIIHUHQFH\QFHLQWHI of wind velocity within the three types studied. Unlike model type (2) and type (3), the model type (1), shows a wind with speed of 5m/s (green) at the entrance under the buildings on VWLOWVZKLFKJUDGXDOOGHFUHDVHVIURPWKHJWKL than 2 m/s at the end of the eighth rows of the buildings. This wind with a speed up to 5m/s is assumed to be able (according to our theoretical studies) to deliver by moving saltation the accumulated sand grains under and between buildings. It seems that the model type (1) (raised 4 m above the ground) can produce a wind velocity of 2-5m/s witch is able to lift the accumulated sand in buildings. However, this velocity tends to decrease as the wind passes through the overhead buildings. We note that it can even equal to zero at the end of the sixth row. (Fig. 11)

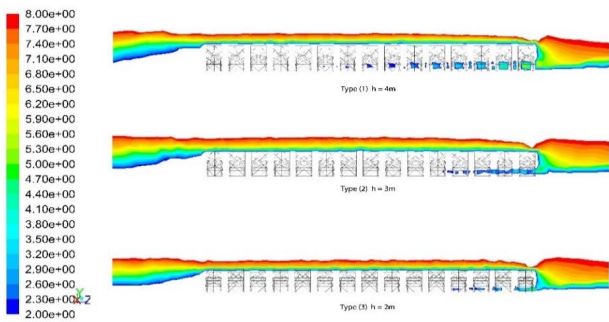


Fig. 11: Longitudinal section showing contours of wind in velocity (m/s) under buildings for the three urban form models.

Velocity less than 2m/s means that the sand grains deposit. We tried a second urban form with only six rows (spaced always 2m) and observe the impact on the evolution of wind velocity under buildings. Our interest would be to have a wind with velocity not less than 2m/s (saltation threshold) travelling all along the urban length (E).

The results in Fig. 12 and Fig. 13 shows clearly that with an urban form of six rows of buildings the wind passes under the buildings with a velocity of 4 m/s. This velocity tends to gradually stabilize around a value of 2 m/s from the end of the fourth row until the end of the sixth one.

With this urban form prototype, (type 1 in Table 2) wind can pass through an urban length (E) of approximate 40 m with an initial velocity of 8m/s. This speed tends to stabilize around a value of 2m/s and maintained it self-cross along the urban length (E = 40 m). According to the literature, the wind of 2 to 4.5 m/s in the built environment could keep the moving sand in saltation without deposition.

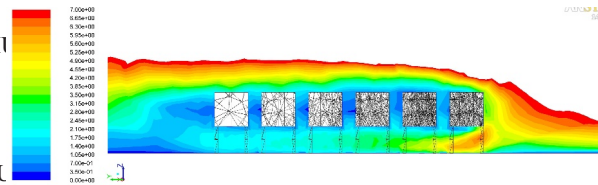


Fig. 12: Wind velocity contours around buildings in an urban length E with six rows.

CONCLUSION

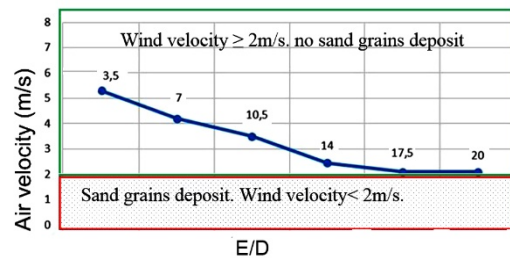
According to our investigation in 2012 on the site of Timimoun, we found that the sand accumulation problem in these areas is due in most of the time to the mechanism of saltation that can start with a wind of 2 to 4.5 m/s.

7KLVSUREOHPRIVDQGDFFXPXODWLRQLVFOHDUOWKHPRVWGLIFX to confront not only because it occurs at regular frequencies of UHJXODU ZLQG UHJLPH7KLV SKHQRPQRQLV DPSOLHGERWZHU physical factors associated with the urban form morphology (H/D, E/D).

In our present modeling, we are interested in the question of accelerating the wind velocity in the general plan. The aim is to ensure a minimum speed not less than 2m/s to avoid any deposition of sand between buildings.

:HKDYHWHVWHGVHYHUDOPRGHOVZLWKWKHFRGH)OXHQWDQGGH the ratio of H/D and E/D in the promising model (1) (Table 2). This model (1) is an urban form compound of six arranged EXLOGLQJVVSDFHGP(DFKURZFRPSULVHVYHYROXPHVVSDFHG PZLWKDGLPHQVLRQ/ P: P+ PDQGK P

This model maintains a constant wind velocity not less than 2m/s under and between raised buildings. According to our theoretical studies, this speed is capable of moving the accumulated sand and remove it out of the urban area (E =40m) with six rows of buildings. (Fig. 13)



)LJ3URQHVRIDLURZYHORFLWDFRUGLQJWRWKHXUEDQ length/Spacing between rows of volumes.

Our future research is to test the relevance of this model by introducing the sand material in the simulation. In addition, the

visualization of the disposal areas would help us to judge the relevance of the model.

ACKNOWLEDGEMENTS

Thanks are due to Biao Wang Ph.D. Student at LRA-Toulouse for his help in simulation with Fluent. Thanks are also due to the staff of Algiers for providing the 15 year (1995-2010) data of Timimoun for analysis.

ENDNOTES

1. Erg: a vast area covered with sand and shifting dunes, as parts of the Sahara Desert.

The Erg is a vast area covered with sand and shifting dunes, as parts of the Earth's land surface and is dominated by xerophytic vegetation. The additional letters h and k are used generally to distinguish whether the dry arid climate is found in the subtropics or in the mid-latitudes, respectively. <http://www.physicalgeography.net/fundamentals/7v.html>

REFERENCES

Ali-Toudert, F. (2000). Wind and bed response during saltation of sand in air. In *Desert Dust: A Global Perspective* (pp. 21-51). Springer Vienna.

Bagnold, R. A. (1941). The physics of wind blown sand and desert dunes. *Journal of the Royal Meteorological Society*, 67(10), 193-215.

Bouvet, F.N. (2003). Wind dynamics in a deep pedestrian canyon under hot weather conditions. *Journal of Wind Engineering and Industrial Aerodynamics*, 80(1), 1-15.

Duchemin, G.J. (1958). Essai sur la protection des constructions contre l'ensablement à Port-Etienne (Mauritanie).

Hosker, R. P. (1985). Flow around isolated structures and building clusters: a review. *Journal of Wind Engineering and Industrial Aerodynamics*, 18(1-2), 1-11.

Hussein, M., & Lee, B. E. (1980). An investigation of wind forces on three dimensional roughness elements in a simulated atmospheric boundary layer. *Journal of Wind Engineering and Industrial Aerodynamics*, 7(1-2), 1-11.

Kok, J. F., & Renno, N. O. (2009). A comprehensive numerical model of steady state saltation (COMSALT). *Journal of Wind Engineering and Industrial Aerodynamics*, 86(1), 1-11.

Mestoul, D., Bensalem, R., Boussoualima, D., Daoudin, M., & Oke, T. R. (2011). Wind, temperature and stability conditions in an east-west oriented urban canyon in an arid climate: case of the ensablement à Touat. *Journal of Wind Engineering and Industrial Aerodynamics*, 88(1), 1-11.

Oke, T. R. (1988). The urban energy balance. *Journal of Wind Engineering and Industrial Aerodynamics*, 32(4), 471-508.

Pethick, J. (1984). An introduction to coastal geomorphology, Edward Arnold.

Santamouris, M., Papanikolaou, N., Koronakis, I., & Mihalakidis, G. (2001). Heat island effects in a deep pedestrian canyon under hot weather conditions. *Journal of Wind Engineering and Industrial Aerodynamics*, 78(1), 1-11.