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Acoustic problems in the new Atlético de Madrid Club Stadium: a change for the worse

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ABSTRACT

The current Wanda Metropolitano Stadium (Madrid, 2017) has acoustic problems. Outdoor, noise emissions to the environment are upper to limit regulatory values. Indoor, the Acoustics is poorer in respect to the old Vicente Calderón Stadium.

Added, changes are observed in the home advantage coefficient of the Atlético de Madrid Club, and the perception of fans and players on the generated sound environment. The soundscape is very different in relation to the old Stadium.

Before the inauguration of the stadium, an acoustic model was developed to study the emissions abroad. After first kick off, it was contrasted by on-site measures. Sport results during 2015-2019 period presents relevant changes on several home advantage coefficients. Now, getting good results at home and passing the round in qualifying competitions until reaching the Final seems more difficult.

Keywords: Crowd noise, Home Advantage, Stadium soundscape
I-INCE Classification of Subject Number: 60

1. INTRODUCTION

In 2017 the Wanda Metropolitano Stadium was inaugurated, being the home stadium for the Atlético de Madrid Club. Originally it was an Olympic stadium since 1994 with capacity for 20,000 spectators. Today it has become a football stadium with capacity for 67,703 people seated.

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During the design of the new stadium the team of architects has not declared any acoustic consultant and the final result has deficits: No attention is paid to the regulatory requirements regarding emissions abroad and different problems have been observed during the different kind of spectacles celebrated in sports arena. Acoustic design of this kind of buildings is complex because it has a multifunctional use, from rock concerts or other types of spectacles to sports meetings.

However, all spectacles must comply with regulations about the levels transmitted outside. It is included in Municipal Ordinance for Protection against Acoustic and Thermal Pollution (OPCAT/2011, city of Madrid) [2] according to Law 37/2003 [3], Directive 2002/49 /CE, about the evaluation and the management of environmental noise.

The designers had to study all contaminating sources: the spectators and the loudspeaker system, traffic flow, energy systems, facilities, security vehicles, helicopters, etc. The most important sources had not been declared and an acoustic consultant had not been appointed [3].

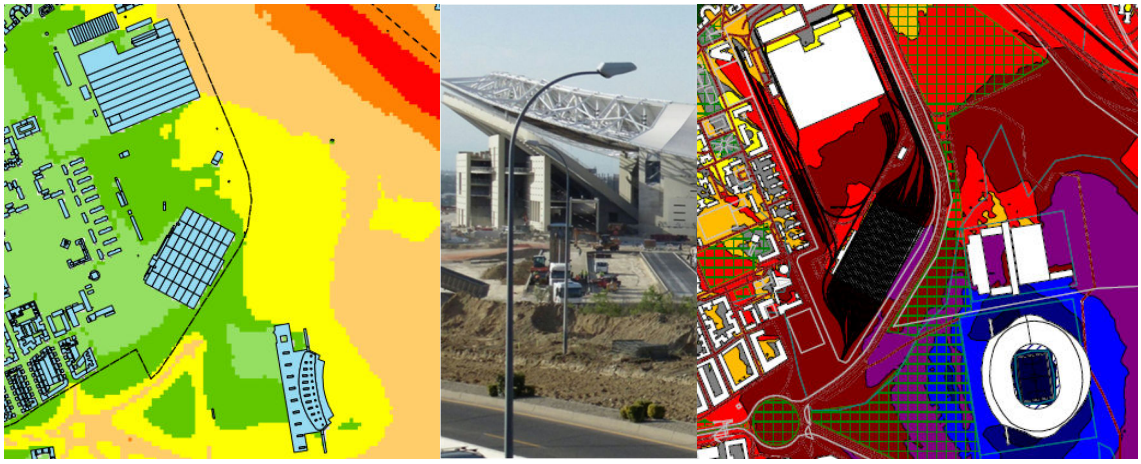


Figure 1: Opening on lateral facade and noise maps after and before the construction works

In addition, the acoustic energy that is transmitted outside reduces the sound levels in the interior. This situation must be studied because this affects the advantage of playing at home (Home Field Advantage - HFA) has different formulas, for example, the quotient between the resulting variable in the home matches and the variable in the total number of matches). Other variables such as the intelligibility and clarity of the signal, linked to reflections on the internal surfaces, can devalue the sound quality of the indoor space.

“From three decades ago, there are findings inside of the psychology of sport that evidence the Home Field Advantage with robust statistical support (Carron, Loughhead, & Bray, 2005) [4]. However, the origin of this advantage is not clear. It has a multicausal relation. The crowd noise from the stands can be very important in the process. These Auditory stimuli influence on: judgment of referee, perception of familiar environment, amplify the answer of territoriality, protect the strategic plan of local team. There are psychological factors too. Chants and sounds have demonstrated some effects in the sport

(Unkelbach, C., Memmert, D., 2010; Van Wijngaarden, S.J., Van Balken, J.A., 2007) [5][6].”

The influence in football competitions has been evaluated during four seasons. In this period we find relevant change in HFA in the UEFA Champions League and “Copa del Rey” tournaments, resulting in more early elimination in both competitions and against easier rivals.

2. METHOD AND RESULTS

In other paper, we are show a previous propagation model and post measures in situ to verify it [7]. The model was created before its inaguration using the software CADNA A, version 4.6., (Datakustic – 2016, according ISO 9613-2: 1999 [8]).

2.1 Creation of the acoustic model

The land lines and other elements (buildings, roads for vehicles, railways, vegetation zones, etc.) are imported. A key element in the design of the model is the horizontal cover of PTPF. It will directly affect the sound environment inside and the outside propagation

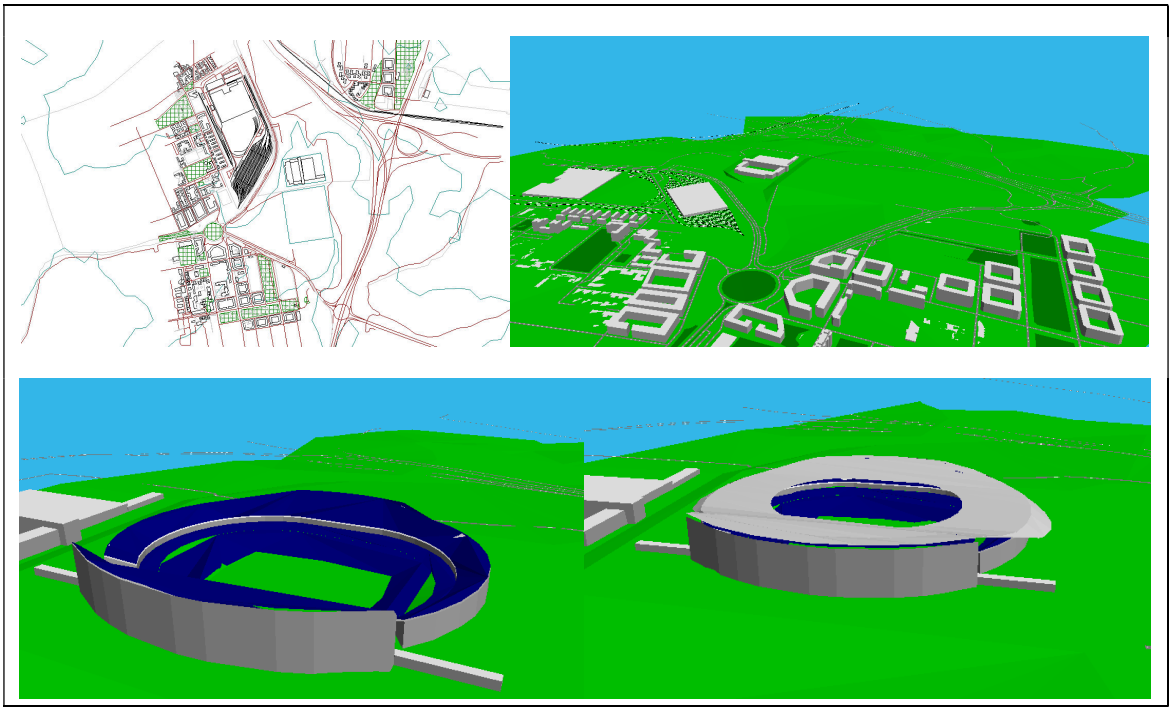


Figure 2: Several phases of model construction

“This cover has been simulated with the 3D reflector tool provided by the CADNA simulation software. This tool allows us to mold and suspend the surface with the approximate shape of the cover and apply some acoustic absorption properties simulating the material that composes it.”

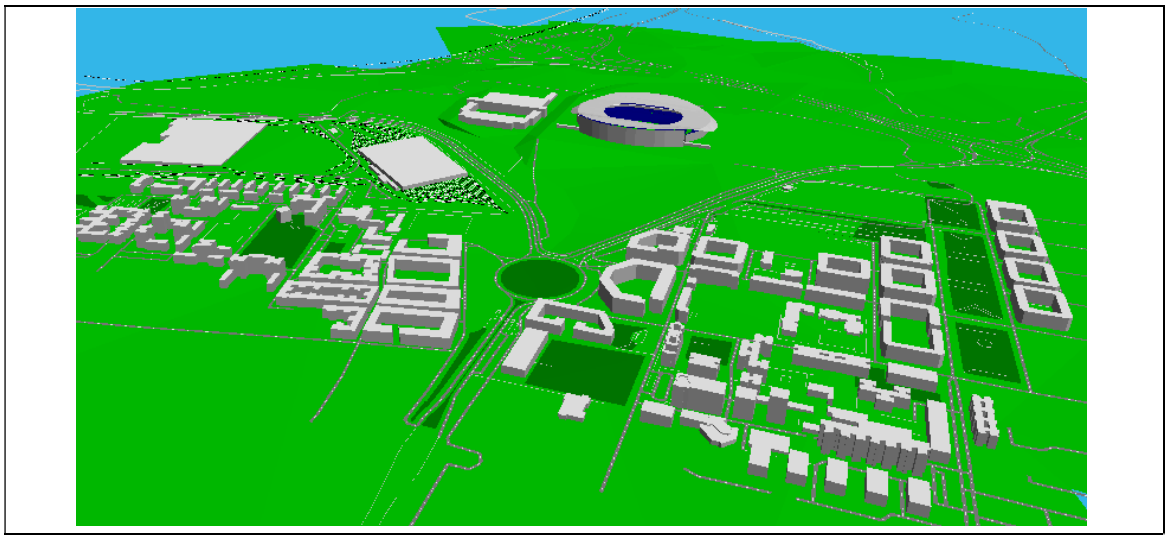


Figure 3: Acoustic Model built

2.2 Location of noise sources

Five sources of noise associated with the stands of the stadium and twelve sources associated with the installed sound system have been considered and distributed as it can be seen below.

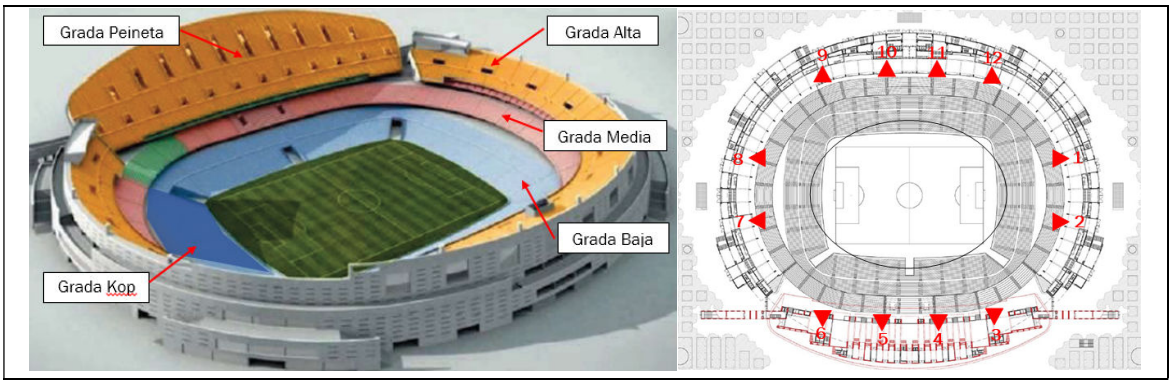


Figure 4: Sound sources surfaces (left) and sound system sources (right)

2.3 Sound level generated by the audience

"To describe the emission of each one of the stands, the data provided in the study by C. Rougier et al. [9] were taken into account. The study presents the data of the level generated by an animation stand during a real football match: on the pitch and measured 1 meter away from it. In the South low stand the 'kop' stand is located."

Table 1: Sound Pressure Level for each sound source surfaces

Octave Band	Normal period		Goal period	
	"kop" stands L_p(dB)	other stands L_p(dB)	"kop" stands L_p(dB)	other stands L_p(dB)
63	74.3	65.8	66.0	73.4
125	81.9	73.4	76.1	80.3
250	86.1	77.6	82.5	85.0
500	89.9	81.4	93.1	93.7
1000	89.1	80.6	97.2	99.3
2000	84.5	76.0	91.2	93.1
4000	77.1	68.6	81.4	82.3
8000	63.4	54.9	69.9	69.3
Global Level dB(A)	92.4	83.9	99.1	101.0

2.4 Sound system

"The configuration used in the simulation model has been the distribution of 12 point sources on the inner part of the cover. This distribution may differ from the one currently installed without affecting the model. Each source was equipped with the directivity characteristics of the Aero 50 models (D.A.S) and the emission characteristics needed to cover the audience areas with sufficient level to meet the intelligibility objectives.

The criterion used was the approval of the emission by the sound system of sufficient acoustic power to cover the different audience areas with a level 10 dB above the noise generated by them during the normal animation. Considering a sound pressure level of 84 dBA in the stands during the normal animation, the level that the sound system should generate over the same area should be about 94 dBA. Under this criterion, the acoustic power of 128 dB has been considered necessary for each of the sources and, thus, the proposed objective could be reached. However, it can be controlled by sound technic ian".

2.5 Verification of the propagation in the model without activity in the stadium

"The propagation in the model is verified in order to contrast the effect of the acoustic propagation in the evaluated environment with the results obtained from the simulated propagation environment. A sound source, with known characteristics, is placed in the studied environment and different samples of the noise generated by it are collected in different locations. Samples are compared with the levels taken in the simulated model with the same source and same evaluation points. The difference between the sequences of values in the points of greater incidence do not seem relevant (difference <6 dB), for that reason the model is validated".

2.6 Verification of the propagation in the model with activity in the stadium

Measurements of sound pressure level were made in the proximity of the stadium during the matches that faced Club Atlético de Madrid versus Sevilla FC (2017/09/23: 2-0) and Chelsea FC (2017/09/27: 1- 2). The values of the noise samples generated in the same evaluation points show an acceptable difference (difference <2 dB) which allows to

confirm the validity of the model. Measures during Iron Maiden and Bruno Mars Concerts show similar results.

Figure 5: Results of model and measuring points during the match ATM vs Sevilla F.C.

Table 3: Measures during different phases of the match

	Chants and voices (dBA)	Megaphone (dBA)	Other sources (dBA)	Background noise (dBA)	Previous model (dBA)	Difference (dBA)
Evaluation period	**10:30 – 15:15**					
Punto 1	**71,7–GOAL 1-0**	64,5	66,2	43,9	**70 - 75**	**< 2**
Punto 2	59,3	59,3	60,1	54,0	---	---
Punto 3	67,3	67,5	71,0	58,3	---	---
Punto 4	75,9	69,2	60,7	<< 60,7	---	---
Punto 5	**91,5–GOAL 2-0**	81,9	---	59,7	**> 85**	**> 6**

2.7 Results of the simulated model

"The predictive model shows that the levels of sound pressure in the proximity of the stadium during the matches or events have worsened the previous situation of the urban environment. The gaps in the facade and the encounter between it and the cover are the main transmission paths".

The levels of sound pressure in the celebration of the goal and the use of the sound system exceed the established limits.

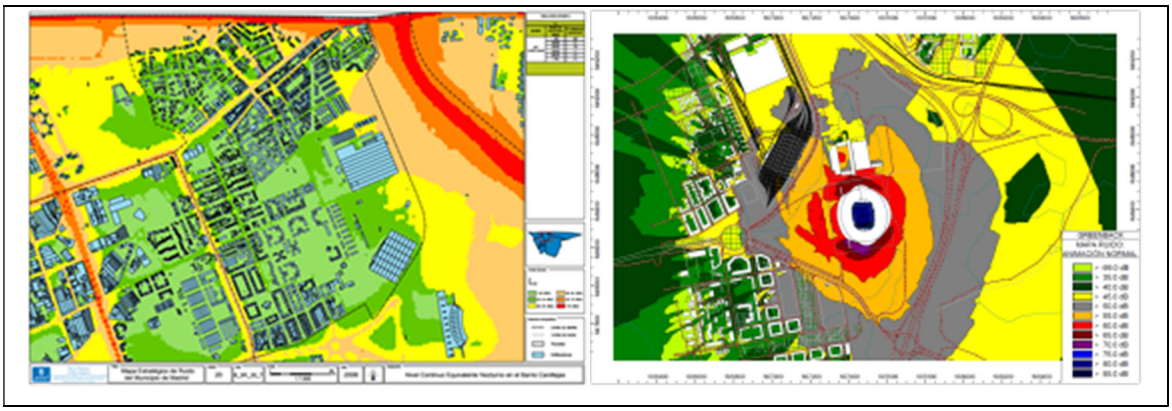


Figure 6: Noise map of the old Stadium vs New Stadium

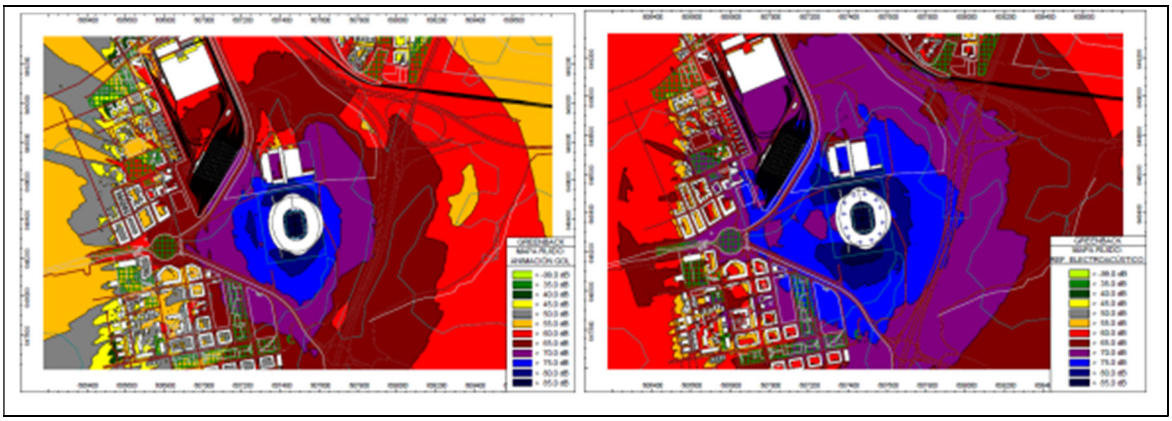


Figure 7: Noise map during goal and use of sound system at New Stadium

3. DISCUSSION

These results can be attributed to the material used in the cover. The acoustic insulation characteristics are defined (Transmission Loss for double PTFE system by Iwaniek, Wiciak et al., 2003) [10]. However an adequate sealing solution that It is effective to prevent the sound from escaping to the outside has not been designed. There are enormous spaces between the cover and vertical enclosures, weakening the global insulation.

Table 2: TL (Plate 1 PTFE 1 mm, acoustic cavity 350 mm, Plate 2 PTFE 0.5 mm)

f	125	250	500	1000	2000	4000	Hz
$R_w \simeq$	10	10	15	20	30	40	dB

Nowadays, due to the increase in acoustic pressure in the vicinity of the stadium, the installation of an enclosure with sandwich panels has begun (Figure 8). But it may not be enough. It may be necessary to plan the isolation of the facades of the residential environment.

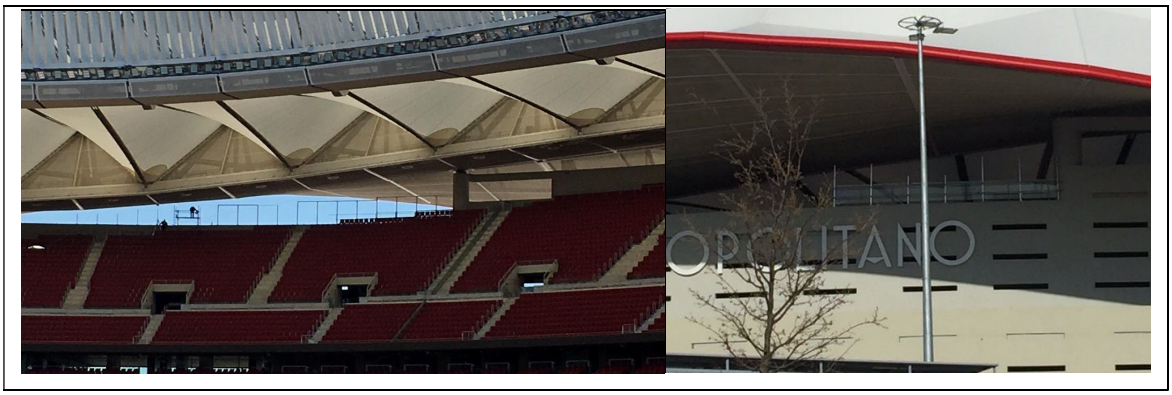
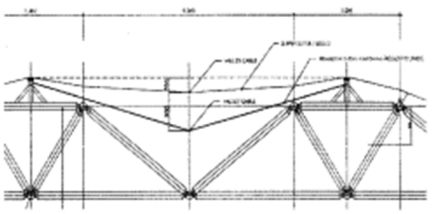
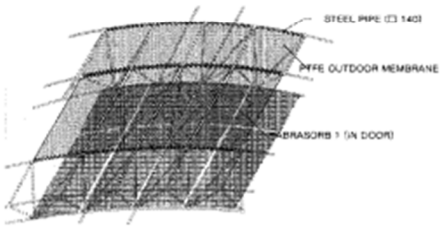


Figure 8: New enclosure between vertical and horizontal envelopes of Stadium [11]

The other acoustic slopes are related to the interior of the stadium. “In this regard, the studies of Dr. Kim et al [12] are really revealing; he warns of the risks of the incorrect use of this material (PTFE) due to the unwanted reverberating effects, which were already discovered after their use in the Korea World Cup. Teflon has reflective qualities inherent to its impermeable quality, necessary to prevent the entry of water. This characteristic should be corrected by a more absorbent inner membrane”. Helped by other solutions, it can reduce the sound emission outdoor.

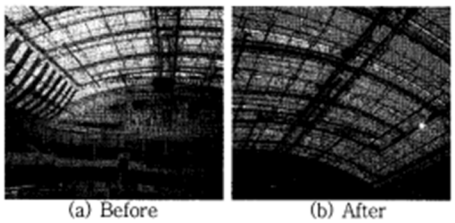


(a) Ceiling detail for the installation of sound absorptive inner membrane material



(b) Isometric drawing of sound absorptive membrane structures

Fig. 12 Sound absorptive membrane structures



(a) Before (b) After

Fig. 13 Before and after installation of sound absorptive membrane material

0.43으로 권장기준 0.6보다 상당히 낮은 것으로 평가되었으나, 흡음내막 설치 시 평균 0.61로 권장기준을 만족하는 것으로 나타났다. 음향특성 측정은 객석이

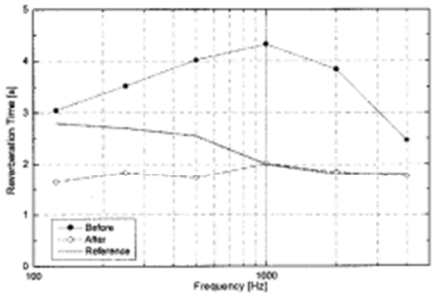


Fig. 14 Average value of reverberation time before and after the installation of sound absorptive membrane material

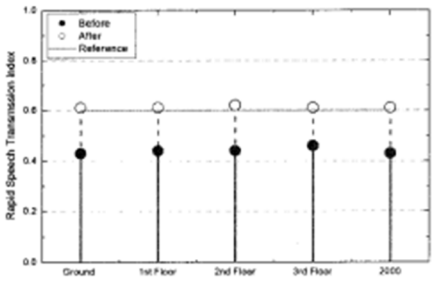


Fig. 15 Average value of RASTI before and after the installation of sound absorptive membrane material

Figure 9: Increased Acoustic Quality for double PTFE system by Dr. Kim

Dr. Kim explai ns the need to add an absorbent inner layer, which would improve the results in terms of reverberation time, intelligibility and other sound quality parameters. His studies display different effects over the teflón use in the envelopes of sport buildings, especially if it has multi-funtional uses."

The acoustic behavior generated by the design and the materials of the cover implies an increase of the sound pressure level in the interior with a difficult control. In addition, the level of acoustic pressure in the exterior increases due to the envelope does not enclose all the volume, it presents gaps between the cover and vertical enclosures. Figure 1.

HFA phenomena can be affected too. If two KO competitions are analyzed during four seasons, two at the Vicente Calderón stadium and two at the new Wanda Metropolitano stadium for the Atlético de Madrid team, the result shows relevant evidences [13]. "Copa del Rey" is a KO domestic competition and UEFA Champions League is an KO European competition.

Table 3: HFA – "Copa del Rey". Red/Vicente Calderón vs White/Wanda Metropolitano

COMPETITION- SEASON	GF H	GC H	PT H	GF F	GC F	PT F	HA GF	HA GC	HA PT	Last Match	Against
Copa del Rey 2015/2016	6	3	6	3	2	6	67%	40%	50%	Quarters	Celta
Copa del Rey 2016/2017	10	6	5	5	9	10	67%	60%	33%	Semi-finals	Barcelona
Copa del Rey 2017/2018	8	2	6	6	4	5	57%	67%	55%	Quarters	Sevilla
Copa del Rey 2018/2019	7	3	4	1	2	5	88%	40%	44%	Round of 16	Girona

Table 4: HFA – UEFA Champions League. Red/VC vs White/WM

COMPETITION- SEASON	GF H	GC H	PT H	GF F	GC F	PT F	HA GF	HA GC	HA PT	Last Match	Against
Champions League 2015/2016	10	2	14	6	5	11	63%	71%	56%	Final	Real Madrid
Champions League 2016/2017	8	2	15	5	9	11	62%	82%	58%	Semi-finals	Real Madrid
Champions League 2017/2018	4	3	4	1	1	4	80%	25%	50%	GROUP Ph.	Roma
Champions League 2018/2019	9	1	11	1	9	4	90%	90%	73%	Round of 16	Juventus

GF H (Goal Favour Home), GF H (Goal Contrair Home), PT H (Points Home), GF F (Goal Favour Far), GF F (Goal Contrair Far), PT F (Points Far). HA GF (Home Advantage Goal favor), HA GC (Home Advantage Goal Contrair), HA PT (Home Advantage Points). Elimination cup score is as follows, Home match (1 point if win, 1 point if no loss, 1 point if any goal received); away match (1 point if win, 1 point if no loss, 1 point if some goal scored). Atlético de Madrid Club played Champion League in old Vicente Calderon Stadium from 2015 to 2017 and then they started playing that competition in Wanda Metropolitan stadium in 2018 and 2019.

The data are poor and a statistical analysis is not possible. But the data suggest that Low HA GC conduces to elimination against easier rivals and earlier phases. HA parameters increase with the change of Stadium, but it conduces to elimination against easier rivals and earlier phases too, according to the analysis of your annual reveneu and sports achievements [14][15].

4. CONCLUSIONS

“The acoustic propagation modeling tool CADNA A has presented accuracy and a sufficient precision to predict the noise emissions in the stadium's urban environment. The sound pressure levels in residential receivers, 400 meters away from the stadium, receive more than 72 dBA at the moments of highest emission, which coincide with the celebration of goals and the use of the sound system. That is, it exceeds the values regulated by more than 20 dB. The envelopes, vertical and horizontal, have not prevented that the interior sound levels are transmitted outside.”

The sound distribution inside the stadium is conditioned by the design of the cover and the distribution of the stands, devaluing the sound quality in the interior space and the perception of the fans and players of the generated sound. The local advantage coefficient (HFA) has changed, so this can impact the sport perfomance and the results of the Club Atlético de Madrid, SAD. Others factors can present influence: economic, technical, tactical, sport planning, etc. But the fact is true: change for the worse, the competition is lost in earlier rounds and against easier rivals.

The absence of acoustic consultant from the early phases of the project and the lack of this type of study has led to a situation of difficult and expensive technical solution. An home field advantage specialist acoustic consultant can be necessary.

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