RT prediction in rooms with non-equally distributed absorption

Alain Bradette - 25 Aug 2004 12:43 GMT

Hello,

I often have to predict reverberation time in rooms like classrooms, gym, open offices and so on. I use Sabin's formula though I know it's wrong but it's simple to use and it's not a catastrophy if the results aren't exactly as predicted. BUT, I'd like to do better by using a more precise formula.

I had a check over the net and found many things. Among them, the Fitzroy's formula modified for 3 axes seems to me the most interesting. There's also a formula from to japanese guys for 2D-RT which looks very interesting in open offices.

But all those things are somewhat theoritical while I'm a consulent engineer and have to "deliver" things that work in the real world. I'd like therefore to hear from you fellows with more experience than me what formula you use in your daily life.

thank you in advance for any help.

Alain Bradette

Reply to this Message

Chris Whealy - 25 Aug 2004 13:42 GMT

Hi Alain

> I often have to predict reverberation time in rooms like classrooms,
> gym, open offices and so on. I use Sabin's formula though I know it's
> wrong but it's simple to use and it's not a catastrophy if the results
> aren't exactly as predicted. BUT, I'd like to do better by using a
> more precise formula.

First, let me say that Sabine's formula is fine rooms in which the total average absorption does not exceed about 0.2; I.E. In reverberant rooms. As the room becomes increasingly absorptive, the numbers produced by Sabine's formula become increasingly unreliable.

(BTW, Wallace Clement SABINE was the man who is generally credited with giving architectural acoustics a scientific foundation. A SABIN [no E] is the unit of absorption named in his honour)

Second, it must be clearly understood that all of the RT60 calculations use statistical approximations in order to derive their answers. This means that the sound field is assumed to be diffuse. This is never possible in reality, but the assumption produces answers that do not differ too much from reality.

Therefore, the concept of increasing "accuracy" must be bounded by the initial statistical limitations of the formulae. It is better to talk about "acceptable" values than "accurate" values.

> I had a check over the net and found many things. Among them, the
> Fitzroy's formula modified for 3 axes seems to me the most
> interesting. There's also a formula from to japanese guys for 2D-RT
> which looks very interesting in open offices.

A bit of history...

Norris & Eyring modified Sabine's to make it more applicable to absorptive environments. Norris & Eyring's formula (for some reason Norris' name is often dropped!) uses ln(1-alpha) in the denominator of Sabine's formula instead of the overall absorption.

Fitzroy's then came along and modified Norris & Eyring's formula to account for unequal axial absorption. This formula produces generally acceptable results and is widely used.

Reinhard Neubauer has modified Fitzroy's formulae to account for the "almost 2 dimensional" sound field described by Toyhama et al.
See http://www.ib-neubauer.com/Literatur/ISSEM_99_Gdansk.pdf for details.

Reinhard has also produced some very good papers on the comparative merits of the various statistical RT formulae. (See http://www.ib-neubauer.com/com/tagungen.php for a list of his papers - in both English and German).

I have taken all of these RT formulae (and two others due to Higini Arau and Millington), and implemented them in a spreadsheet which you can download for free from http://www.rmmpnet.org/members/ChrisW/index.html

There are several acoustic calculation spreadsheets there, but the one that is probably of immediate interest is the Control Room Calculator. This spreadsheet allows you to place up to four different materials on each of the six room surfaces, and calculates the RT60 value (plus a whole load of other values) using various formulae. Please follow read the instructions carefully in order to get the spreadsheet to work properly.

> But all those things are somewhat theoritical while I'm a consulent
> engineer and have to "deliver" things that work in the real world. I'd
> like therefore to hear from you fellows with more experience than me
> what formula you use in your daily life.

With the advent of cheap desktop computers (I.E. in the last 15 years), the drive to find increasingly accurate statistical formulae for RT values has dropped off, and been replaced with software that does 3 dimensional acoustical modelling. See the CATT Acoustic product for a good example of such a product (http://www.catt.se).

I would appreciate your feedback on how useful you find my spreadsheets.

Regards

Chris W

⊞Signature

Reply to this Message

Georgios Natsiopoulos - 25 Aug 2004 23:12 GMT

Just an additional comment (or reminder):

Even with the best theory, the reliability of the results are never better than the accuracy of the input data.

An error analysis (differentials) for Sabine's formula is advisable and instructive, especially if there are large hard surfaces in the room. Errors in the absorption coefficient data of +/-5 units of percent are not uncommon at all.

If you ("you" as in "anyone" of course) can't estimate the error somehow, you really must admit that you don't know what you are talking about :)

Best regards,
Georgios

> Hi Alain
>
[quoted text clipped - 75 lines]
>
> Chris W

Reply to this Message

Chris Whealy - 26 Aug 2004 10:43 GMT

Quite so Georgios...

Let me further add that when estimating the RT of an enclosed space with highly reflective surfaces (say an empty basement room with concrete floor and walls), then the resulting RT value becomes highly sensitive to the initial absorbency conditions.

If you use an absorbency value of say, alpha = 0.01 @ 125Hz, but then repeat the calculation with alpha = 0.02 @ 125Hz, you could get as much as a 30% difference in the resulting RT value!

The whole concept of calculating RT values using statistically based formulae can, at best, only give a reasonable suggestion as to the rate of decay of energy in the sound field.

Oh, and I've just remembered one more thing that annoys me about the way RT values are quoted.

A sound field reverberating in an enclosed space has lower frequency limit, below which the field cannot be considered "diffuse". This frequency in known as the Schroeder frequency, and indicates the point at which the modal density has become sufficiently low, that individual modes are just starting to become perceptible. The principle here is that the smaller the room volume, the higher the Schroeder frequency.

All the RT formulae derived by Sabine, Norris & Eyring, Fitzroy, Arau and Millington etc., are all based on the assumption that the sound field is diffuse. Yet how many times do you see people quoting RT values for control rooms right down to 64Hz, when the room has a Schroeder frequency of say 220Hz! This is gross misuse of the calculations, because the figures they produce are not being used within the boundaries of accuracy. It appears that not too many people realise this - hence the proliferation of this error.

If you want to a truly "accurate" value for reverberation time, then use
a 3D acoustic modelling package. E.G. http://www.catt.se

Regards

Chris W

⊞Signature

Reply to this Message

Georgios Natsiopoulos - 26 Aug 2004 12:32 GMT

I agree.

Note that the 3D modelling programs (CATT and Odeon at least) use small variations of ray tracing algorithms as engines and also have their severe limitations when it comes to relatively small rooms and low frequencies - control rooms for example.

In order to take scattering and other effects into account properly, the algorithm should be based on the wave equation itself, or an acceptable approximation of it (not the ray tracing approx. which is too crude for some room acoustic purposes).

Georgios
"Go ahead and faith will come to you" (d'Alembert)

> Quite so Georgios...
>
[quoted text clipped - 36 lines]
>
> Chris W

Reply to this Message

Higini Arau Puchades - 27 Aug 2004 01:20 GMT

Chris Whealy <chris.whealy.NO@SPAMsap.com> wrote in message news:<cgkbb6

> All the RT formulae derived by Sabine, Norris & Eyring, Fitzroy, Arau
> and Millington etc., are all based on the assumption that the sound
[quoted text clipped - 11 lines]
>
> Chris W

Dear friends of this discussion and special for Chris Whealy by his efforts realised about this sense with his software.

It is known that the classical mean free path obeys a normal (or gaussian law), because it only makes sense when a diffuse sound field exists, that is to say when one has an uniform disposition of the absorption in the enclosure.
We know, [2], [3], that the absorption exponent, a, is proportional to the sound decay rate, D, produced by the sound reflected after that the sound collision has been produced above each one wall of the room. When the absorption is constant implies that D is ever constant. When the decay or the absorption is almost constant, with little differences among them, then the arithmetical weighted mean by the area fraction is a good predictor of the behaviour of the sound in the enclosure. This arithmetical mean predictor is characteristic of the symmetrical curves, such is so the Gauss bell curve.

Therefore we have that the classical mean free path and the arithmetical mean treatment of the absorption coefficients are of equivalent nature. Although the sequential and simultaneous reflections against walls are produced, as these surfaces have a similar properties of absorption, then the final result are independent of the type of sound collision that be produced. So we have that all absorption exponents of Sabine, Eyring, Millington and Cremer, only can be applied when we have a constant, or almost constant, absorption distribution, then the arithmetical weighted mean by the area fraction in all the cases, is:
a= (1/S) sum alfai Si , i = 1 to 6, being S = sum Si
being for each case: alfai = alfa is for Sabine;
a = alfaEyr = - ln (1- alfa), where is alfa= (1/S) sum alfai Si for Eyring;
ai = alfai Mil = - ln (1- alfai) for Millington;
alfai = alfaiCre = - ln (1- (1/Si)sum alfaj Sj), being Si = sum Sj ,for Cremer;
Fitzroy formula: is an only experimental formula
By another hand, it is easily derived that the exponent absorption proposed by Fitzroy is an harmonic weighted mean given by the following expression:
aFitz = (1/ax (Sx / S) +1/ay (Sy / S) + 1/az (Sz / S)) -1
where are: ax = - ln (1- alfax)
ay = - ln (1- alfay)
az = - ln (1- alfaz) , being alfax, alfay, alfaz the mean absorption coefficients of areas Sx, Sy, Sz.
In this case the sequentially of the reflections is assured through the arithmetic mean of absorption coefficients between each pair of parallel boundaries. But the harmonic weighted mean of the partial absorption exponents is not good predictor to obtain the mean true of the sample of values, because the mean absorption exponent wished can not depend of the reciprocal of the partial absorption exponents defined. This is a bad mean by two reasons.
1)Because it means that it does not response to true nature of case, in that increasing anyone of the partial absorption exponents it produces an increasing of the mean value.
2)This mean is strongly incompatible with the normal law of the classical mean free path.

H.Arau -Puchades Formula
In this case solving my equation (31), [3], was replaced ai by log ai; it is usual in statistical to obtain a logarithm-normal distribution of the sample. When the values of sample are few, and very unequal, it is good interchange the true values by their logarithm, [4], because the highest, or smallest, values affect less to the geometrical mean than the arithmetical mean. Moreover this mean is used when the variation of values correspond to equal intervals of time, and I remember that in reality in this case, for non uniform absorption distribution, the different decay rates produced are compared.
By another hand, this geometrical weighted mean is compatible with the normal law of the classical mean free path, because the sample of values of ai, or Di, have acquired a normal statistical tendency.
Moreover with this mean is assured the simultaneously of the sound reflections above perpendicular walls, while than the sequentiality is assured through the arithmetic mean of the absorption coefficients between each pair of parallel surfaces.
Using this logarithm-normal distribution it has been possible to define a factor of dispersion, d, that enables us to calculate the first reverberation time portion, or EDT.
Therefore: Sabine, Eyring, Millington, Cremer, kuttruff, (perhaps

Fitzroy also) formulae are only valid for diffuse cases. But Arau formula never.

Now I realise here a comparison among calculated from several theories and measured by S.Bistafa-J.Bradley (*), omitting to expose the Millington RT by very bad results derived, writing the real values obtained by application the Cremer expression (without D),and with D appling the Dance and Shield correction (1) that transforms the Cremer expression near to Sabine expression.
Also I expose in certain cases CATT calculations in where we need to add diffusion to get aproach the results derived to measured values.

(*): Predicting reverberation times in simulated classrooms. J.Acoust. Soc. Am. Vol 108 nº4 (2000).

1.The alfa-values were obtained using the Eyring formula and the reverberation times presented for the case 0:

	125	250	500	1000	2000	4000
alfa	0,023	0,026	0,0245	0,027	0,031	0,034

2.The m-values used were:

	125	250	500	1000	2000	4000
m	0,00002	0,00006	0,0002	0,0006	0,002	0,006

The name of each case is given by Bistafa-Bradley

CASE 0

RT	125	250	500	1000	2000	4000
Measured	5,75	5	5,25	4,6	3,5	2,4
Sabine	5,793	5,088	5,297	4,598	3,543	2,475
Eyring	5,727	5,022	5,234	4,54	3,497	2,448
Cremer	5,727	5,022	5,234	4,54	3,497	2,448
Cremer-D	5,793	5,088	5,297	4,598	3,543	2,475
Kuttruff	5,753	5,048	5,259	4,563	3,516	2,459
Fitzroy	5,727	5,022	5,234	4,54	3,497	2,448
Arau	5,727	5,022	5,234	4,54	3,497	2,448

CASE 25

RT	125	250	500	1000	2000	4000
Measured	5,4	2,7	1,55	1,3	1,3	1,25
Sabine	5,033	2,591	1,646	1,368	1,37	1,367
Eyring	4,966	2,524	1,579	1,302	1,311	1,324
Cremer	4,962	2,467	1,462	1,178	1,215	1,273
Cremer-D	5,047	2,786	2,052	1,795	1,683	1,526
Kuttruff	4,921	2,389	1,429	1,166	1,197	1,249
Fitzroy	5,066	3,429	3,218	2,805	2,318	1,829
Arau	5,015	2,942	2,258	1,914	1,747	1,56

CASE 50

RT	125	250	500	1000	2000	4000
Measured	4,55	2,1	1,1	1,1	1,05	1
Sabine	4,449	1,738	0,974	0,803	0,849	0,944
Eyring	4,382	1,671	0,907	0,736	0,786	0,893
Cremer	4,37	1,565	0,728	0,543	0,624	0,789
Cremer-D	4,463	1,859	1,18	1,021	1,027	1,054
Kuttruff	4,362	1,599	0,818	0,648	0,71	0,84
Fitzroy	4,665	3,119	3,028	2,654	2,181	1,717
Arau	4,521	2,284	1,652	1,389	1,309	1,248

CASE 75

RT	125	250	500	1000	2000	4000
Measured	3,7	1,55	1,1	1,3	1,1	1
Sabine	3,985	1,306	0,691	0,568	0,614	0,72
Eyring	3,918	1,239	0,623	0,499	0,549	0,665
Cremer	3,896	1,099	0,395	0,228	0,327	0,516
Cremer-D	3,993	1,354	0,767	0,65	0,684	0,767
Kuttruff	3,951	1,214	0,563	0,434	0,494	0,63
Fitzroy	4,395	2,987	2,956	2,596	2,127	1,67
Arau	4,149	1,922	1,337	1,11	1,069	1,063

CASE 100

RT	125	250	500	1000	2000	4000
Measured	3,4	1,35	1,2	1,4	1,1	1
Sabine	3,698	1,102	0,568	0,466	0,51	0,612
Eyring	3,631	1,034	0,499	0,397	0,443	0,555
Cremer	3,6	0,874	0,215	0	0,111	0,372
Cremer-D	3,698	1,106	0,574	0,472	0,515	0,616
Kuttruff	3,703	1,031	0,451	0,34	0,396	0,529
Fitzroy	4,246	2,93	2,925	2,572	2,103	1,649
Arau	3,926	1,736	1,174	0,962	0,941	0,963
Catt 0% scat						
T15	5,6	4,35	3,98	3,49	2,68	1,81
T30	6,85	5,46	3,88	3,16	3,01	2,16
Catt 10% scat						
T15	3,76	1,51	1,33	1,2	1,08	0,96
T30	3,77	1,56	1,48	1,38	1,25	1,05

CASE HR

RT	125	250	500	1000	2000	4000
Measured	4	2,1	1,35	1,35	1,2	1,1
Sabine	4,449	1,738	0,974	0,803	0,849	0,944
Eyring	4,382	1,671	0,907	0,736	0,786	0,893
Cremer	4,37	1,565	0,728	0,543	0,624	0,789
Cremer-D	4,463	1,859	1,18	1,021	1,027	1,054
Kuttruff	4,362	1,599	0,818	0,648	0,71	0,84
Fitzroy	4,665	3,119	3,028	2,654	2,181	1,717
Arau	4,521	2,284	1,652	1,389	1,309	1,248

CASE HS

	125	250	500	1000	2000	4000
Measured	4,2	2,05	1,5	1,5	1,3	1,1
Sabine	4,449	1,738	0,974	0,803	0,849	0,944
Eyring	4,382	1,671	0,907	0,736	0,786	0,893
Cremer	4,37	1,565	0,728	0,543	0,624	0,789
Cremer-D	4,463	1,859	1,18	1,021	1,027	1,054
Kuttruff	4,362	1,599	0,818	0,648	0,71	0,84
Fitzroy	4,665	3,119	3,028	2,654	2,181	1,717
Arau	4,521	2,284	1,652	1,389	1,309	1,248
Catt scat 0%						
T15	3,89	3,32	3,32	3,3	2,6	2,35
T30	4,58	3,9	3,73	3,29	2,71	2,08
Catt scat 10%						
T15	3,36	1,93	2,02	2,08	2,02	1,92
T30	3,54	1,86	1,64	1,63	1,56	1,45

CASE EW

RT	125	250	500	1000	2000	4000
Measured	4,65	2,15	1,8	1,6	1,45	1,15

Sabine   4,449   1,738   0,974   0,803   0,849   0,944
Eyring   4,382   1,671   0,907   0,736   0,786   0,893
Cremer   4,362   1,475   0,432   0   0   0,663
Cremer-D4,456   1,788   1,045   0,873   0,909   0,986
Kuttruff4,303   1,552   0,802   0,64   0,698   0,822
Fitzroy   4,757   2,979   2,586   2,24   1,929   1,616
Arau   4,588   2,343   1,61   1,336   1,292   1,262
Catt scat 0%
T15   4,64   2,55   2,1   1,83   1,59   1,24
T30   4,85   3,4   3,11   2,66   2,1   1,53
Catt scat 10%
T15   4,39   1,68   1,01   1,03   0,98   0,93
T30   4,37   1,71   1,07   1,03   1   0,94

CASE PW
RT   125   250   500   1000   2000   4000
Measured3,9   1,8   1,1   1,1   1,1   1
Sabine   4,449   1,738   0,974   0,803   0,849   0,944
Eyring   4,382   1,671   0,907   0,736   0,786   0,893
Cremer   4,379   1,644   0,864   0,692   0,748   0,868
Cremer-D4,472   1,925   1,284   1,126   1,113   1,109
Kuttruff4,279   1,541   0,807   0,65   0,704   0,823
Fitzroy   4,608   2,898   2,732   2,392   1,994   1,61
Arau   4,491   2,163   1,501   1,257   1,207   1,181

CASE PF
RT   125   250   500   1000   2000   4000
Measured3,95   1,95   1,15   1,1   1,1   1
Sabine   4,449   1,738   0,974   0,803   0,849   0,944
Eyring   4,382   1,671   0,907   0,736   0,786   0,893
Cremer   4,37   1,565   0,728   0,543   0,624   0,789
Cremer-D4,463   1,859   1,18   1,021   1,027   1,054
Kuttruff4,362   1,599   0,818   0,648   0,71   0,84
Fitzroy   4,665   3,119   3,028   2,654   2,181   1,717
Arau   4,521   2,284   1,652   1,389   1,309   1,248

Error absolute of all cases
erabs (%)   1 kHz   500 Hz - 2 kHz   125 Hz - 4 kHz
ErrSab.   34,6   28,8   20,1
ErrEyr.   38,4   32,6   23
ErrCre.   55,5   48,5   33,3
ErrCre-D.27,3   23,2   16,6
ErrKut.   44,5   38,5   27,1
ErrFit.   91,4   94,1   67,1
ErrArp.   18,8   18,6   15,4

Error relative of the all cases
err (%)   1 kHz   500 Hz - 2 kHz   125 Hz - 4 kHz
ErrSab.   -33,6   -27,6   -16,9
ErrEyr.   -38,4   -32,5   -20,9
ErrCre.   -55,5   -48,5   -31,6
ErrCre-D.-19,2   -14,4   -8,2
ErrKut.   -44,5   -38,5   -25,3
ErrFit.   91,1   94   66,8
ErrArp.   4,6   11,1   11,2

As we can to see nothing is exact nor exactly true, but we can to work hard to get it some day. I pray excuse to you for this exposition very much large.
Sincerely yours

Higini

BIBLIOGRAPHY
[1] S. Dance and B. Shield. (2000) Technical note: Absorption Coefficients of Common Construction Materials for use in computer modelling. J. Building Acoustics. Vol. 7 n. 3.
[2] R.W. Young (1959) Sabine reverberation equation and sound power calculations. J. Acoust. Soc. Amer. 31, 912.
[3] H.Arau-Puchades (1988) An improved Reverberation Formula. Acustica Vol.65.
[4] Sachs, L. (1978) Estadística Aplicada. Ed. Labor, S.A., S.1.3.8, 1.3.9, 7.3.3.
[5] Higini Arau (1998) General theory of the Energy Relations in Halls with Asymmetrical Absorption. J. Building Acoustics. Vol. 5 n. 3
[6] Higini Arau (1999) ABC de la Acústica Arquitectónica. Ediciones Ceac.

Reply to this Message

Chris Whealy - 27 Aug 2004 11:49 GMT

> Dear friends of this discussion and special for Chris Whealy by his
> efforts realised about this sense with his software.

Señor Arau-Puchades! Thank you for your lengthy reply! I will certainly study it in detail when I have the time.

Regards

Chris W

⊞Signature

Reply to this Message

Angelo Campanella - 27 Aug 2004 05:27 GMT

> Even with the best theory, the reliability of the results are never better
> than the accuracy of the input data.

The problem is that the Sabine relation is a one-dimensional theory, while the phenomenon proceeds in a 3-dimensional space. The Fitzroy theory has been found to agree much better with real measurements. The eyring theory applies when the absorption is not trivial but much more than what Sabine investigated.

> An error analysis (differentials) for Sabine's formula is advisable and
> instructive, especially if there are large hard surfaces in the room. Errors
> in the absorption coefficient data of +/-5 units of percent are not uncommon
> at all.

That error analysis will not tell us anything worth while in this context. We know that the Sabine relation is not intended for nonunifom rooms and rooms with poor diffusion. This is what Fitzroy faced in California 50 years ago as a practical consultant. His X, Y, Z relations were coined to answer the problem.

You MUST study Fitzroy's paper (mid fifties JASA).

Angelo Campanella

Reply to this Message

Georgios Natsiopoulos - 27 Aug 2004 07:57 GMT

Thank you for your answer.

An error analysis is always worthwhile in order to know how much errors in different input data parameters affect the result. The Sabine equation was just an example, I admit that I could have been more clear there.
The point is that if you don't know how much error you do, you don't know how correct you are - almost a tautology - but important nevertheless.

Georgios

> > An error analysis (differentials) for Sabine's formula is advisable and
> > instructive, especially if there are large hard surfaces in the room. Errors
[quoted text clipped - 6 lines]
> California 50 years ago as a practical consultant. His X, Y, Z relations
> were coined to answer the problem.

Reply to this Message

Angelo Campanella - 28 Aug 2004 03:39 GMT

> Thank you for your answer.
> An error analysis is always worthwhile in order to know how much errors in
> different input data parameters affect the result. The Sabine equation was
> just an example, I admit that I could have been more clear there.
> The point is that if you don't know how much error you do, you don't know
> how correct you are - almost a tautology - but important nevertheless.

I presume that you have not done that error analysis yet, nor do you intend to do so...

Ang. C.

Reply to this Message

Georgios Natsiopoulos - 30 Aug 2004 10:13 GMT

I have done error analyses, but just for Sabines formula in acoustics.
It wouldn't be much more difficult to do it for the other variations of the reverberation formulae.

I read the Fitzroy article some year ago and found it interesting and easy to use, at least for rectangular rooms.

Error analyses may be replaced or at least augmented by the less quantitative tools of common sense based on experience, even if it less elegant in my opinion. But who cares as long as the result is good enough to get away with it, right? :)

Well I do care, but ok, it is mostly for egoistic/aesthetical reasons:
To strive for perfection - wouldn't be fun or interesting otherwise.
After all, most mistakes can be corrected afterwards if necessary - the question is who pays.

Georgios Natsiopoulos

"Beware of the man who works hard to learn something, learns it, and finds himself no wiser than before. He is full of murderous resentment of people who are ignorant without having come by their ignorance the hard way."
-- Bokonon

> > Thank you for your answer.
> > An error analysis is always worthwhile in order to know how much errors in
[quoted text clipped - 7 lines]
>
> Ang. C.

Reply to this Message

Angelo Campanella - 30 Aug 2004 16:12 GMT

> I have done error analyses, but just for Sabines formula in acoustics.
> It wouldn't be much more difficult to do it for the other variations
> of the reverberation formulae.

What have you used for input data?

Consider this:

For a variety of room arrangements, but of the same volume, and with the same area of sound absorbing material, and the same material, a wide variety of reverberation times result, sometimes as much as a factor of two. Now, to which factor in the Sabine relation do you attribute he error?

Angelo Campanella

Reply to this Message

Brian Marston - 25 Aug 2004 15:36 GMT

> Hello,
>
[quoted text clipped - 17 lines]
>
> Alain Bradette

Alain,

I personally find the so-called Fitzroy formula reasonably accurate for most situations with generally good agreement between the pre-measured reverberation times and the calculated reverberation times. (It also isn't too tedious on the calculations).

I've only (just a few minutes ago) finished off a set of calcs for a 400 seat hall I measured yesterday. Sabine equation calcs didn't even come close to fitting the measured values but Fitzroy fitted very closely. The hall officially opens in 4 weeks and they were not impressed with 5 to 6 seconds at 1000Hz. With luck the new ceiling finish should be in just in time for the opening.

Brian
Consulting Acoustical Engineer
(from Down Under).

Reply to this Message

Alain Bradette - 26 Aug 2004 12:11 GMT

Thank you very much Chris for your comprehensive answer.

I send my post rigth after reading an article for Neubaeur which compares meany calculation methods.
http://sound.eti.pg.gda.pl/papers/prediction_of_reverberation_time.pdf

All the methods have theirs limitations which I'm aware of. Since most of the time I'm not facing situations that totally complies with the methods' assumptions, I was just wondering what greatly experienced acousticians use. But now, having your spreadsheet Chris, I can choose which RT calculation seems to fit better according to each situation.
It's a remarquable tool you build!

Talking of your spreasheet, how can I edit the absorption coefficient database? I'd like to add some materials.

I worked some time ago with Odeon, an equivalent of CATT. It's really a nice tool, but it's not necessary to have such a powerfull software when it comes to calculate RT in classrooms and other simple room of this kind. I mean, it would be fine, but I'll never get the budjet for this!

Brian, 5 to 6 sec at 1000Hz in a hall seems to me awfully long. Would the ceiling provide all the necessary absorption? The absorption doesn't look very balanced if I may say a comment.

Alain Bradette
(from the 60th parallel North)

Reply to this Message

Chris Whealy - 26 Aug 2004 14:31 GMT

Hi Alain

> http://sound.eti.pg.gda.pl/papers/prediction_of_reverberation_time.pdf

Good paper! I've had a quick glance through it, but unfortunately, I have no time at the moment to read it in detail. [I'm only do acoustics as a hobby, and I'm busy writing a book about a soon-to-be-released software product written by the company I work for - nothing to do with acoustics... :-( ]

> It's a remarquable tool you build!

:-) I built it because I wanted to prove to myself that I understood
the concepts involved. Then one thing led to another, and it became much larger than I originally anticipated...

> Talking of your spreasheet, how can I edit the absorption coefficient
> database? I'd like to add some materials.

At the moment, each material in the database is identified by a hard coded id. I decided not to allow the users to create their own material id's, because it could lead to all sorts of software problems. Therefore, if you scroll down on sheet "Absorption Coefficients", you'll see that the last item in each surface category is called "User defined <category>". The absorbency fields next to each of these user defined materials are open for input. You may enter your own values here.

Just because the description of the material says something like "User defined ceiling" does not mean that you have to apply this material to the surface called "Ceiling". If the database contains the surface material you require, then you can use the user defined material in that category for any other surface in the room.

> I worked some time ago with Odeon, an equivalent of CATT. It's really
> a nice tool, but it's not necessary to have such a powerfull software
> when it comes to calculate RT in classrooms and other simple room of
> this kind. I mean, it would be fine, but I'll never get the budjet for
> this!

True!

> Brian, 5 to 6 sec at 1000Hz in a hall seems to me awfully long.

Whether or not an RT of 5 to 6 seconds should be considered long depends on the volume of the room. An RT of 5 seconds in a room of 20,000 m^3 is probably OK, but in a 150 m^3 classroom is horrible!!

> Would the ceiling provide all the necessary absorption?

I think applying absorbency only to the ceiling would not help because you are treating only one axis of the room. I think a speaker at one end of the room would experience problems with late echoes off the opposite wall if the vertical axis has been treated, but the horizontal axes are still reflective.

> The absorption doesn't look very balanced if I may say a comment.

I don't know the geometry of the room you are treating, but I would recommend trying to distribute the absorbency as evenly as possible - especially in the horizontal plane.

Regards

Chris W

⊞Signature

Reply to this Message

⊟**Angelo Campanella** - 27 Aug 2004 05:40 GMT

> Hi Alain
>> http://sound.eti.pg.gda.pl/papers/prediction_of_reverberation_time.pdf
> Good paper! I've had a quick glance through it, but unfortunately, I

I've used that stuff for years. Works as good as can be expected. Kostek was kind enough to plug through some higher math to please the aesthetics among us. Hear, Hear!

Ang. C.

Reply to this Message

⊟**Brian Marston** - 28 Aug 2004 23:43 GMT

> Hi Alain
<SNIP>

>> Brian, 5 to 6 sec at 1000Hz in a hall seems to me awfully long.
> Whether or not an RT of 5 to 6 seconds should be considered long depends
[quoted text clipped - 15 lines]
> Regards
> Chris W

Yes, it sound horrible !

Hall ~ 28 metres by 18 metres with side wall height of 4 metres with pitched ceiling rising to about 6 metres in the centre. Floor area ~ parquetry on concrete. About 2500 cubic metres. School Auditorium / basketball court! Stage with heavy drapes at one end. Use of walls limited by use of hall and budget.

Reply to this Message

⊟**Chris Whealy** - 29 Aug 2004 21:25 GMT

Hi Brian

> Yes, it sound horrible !
>
[quoted text clipped - 3 lines]
> basketball court! Stage with heavy drapes at one end. Use of walls

> limited by use of hall and budget.

If possible, apply absorbency to the walls to bring the RT down. Then try to ensure that the pitched roof space is subdivided with heavy drapes to reduce resonance above the audience area.

If there is going to be predominantly speech in there, you'll want to aim for an RT60 between 0.9 and 1.4 secs, and for music, an upper limit < 2.2 secs.

Regards

Chris W

⊞Signature

Reply to this Message

Georgios Natsiopoulos - 04 Sep 2004 19:40 GMT

----- Original Message -----
From: "Alain Bradette" <abr@norconsult.no>

> But all those things are somewhat theoritical while I'm a consulent
> engineer and have to "deliver" things that work in the real world.

Those kinds of sentences will generally annoy and hurt us theorists who have insight in and working experience from "the real world". :)

This is a common problem I guess. Of course there are ways to deliver things cheaper and faster by cheating (if you can get away with it), and thereby making more expensive, but in the long run better, alternatives less competitive. Inflation. Downward spiral.

There is always the option to refrain from delivering and leave the problem for others better suited for the task.
Or talk to your boss and ask for more time.
This would require a lot of courage - I know.

But ok, perhaps it would be throwing pearls for the swine anyway, as long as the end user doesn't complain.

I don't know you (nor myself) well enough to pass judgments - this is a general comment that seemed suitable in this context.

Georgios

Reply to this Message

Find more on: **arau acoustics**