

## ANALYSIS OF COOLING DEGREE DAYS FOR TIRUCHIRAPPALLI – A DISTRICT IN INDIA

S.Shanmuga Priya<sup>1\*</sup>, M.Premalatha<sup>2</sup>, S.R.Rajkumar<sup>3</sup> & I.Thirunavukkarasu<sup>4</sup>

<sup>1</sup>Department Of Chemical Engineering/<sup>4</sup>Department Of Instrumentation And Control Engineering  
Manipal Institute Of Technology, Manipal University, Manipal-576 104, Karnataka. India.

<sup>2,3</sup>Centre For Energy & Environmental Science And Technology  
National Institute Of Technology, Tiruchirappalli 620015, Tamil Nadu, India.

\* E-mail: shanprianitt@yahoo.co.in, latha@nitt.edu

### ABSTRACT

In India the performance of buildings may take a greater significance in near future with the constraint of limited resource availability, domestic and international targets for the reduction of green house gas emissions. For India, annual cooling degree days are 3120 and annual heating degree days are 80. In this study, cooling degree days for Tiruchirappalli, a location in south part of India is found using the long-term recent measured data by British gas method. Cooling degree days are calculated for eleven base temperatures ranging from 18°C to 28°C and are tabulated. Annual cooling degree days is related with base temperature for Tiruchirappalli with the correlation coefficient of 0.995. Also, an empirical relation between the month and monthly average cooling degree days is obtained with the correlation coefficient of 0.942. Heat loss calculations are carried out for Indian buildings as a function of annual cooling degree days for different U values of buildings. The results are compared between the best and worst U values of the buildings. The calculations are also made for heat loss for different base temperatures keeping the U value of the building constant. The results indicate that either a correction in base temperature or a better U value for the buildings will save energy up to an extent of 80% in air-conditioned Indian buildings.

**Keywords:** *Cooling degree days; Base temperature; Heat loss ; Building Energy consumption ; Tiruchirappalli.*

### 1. INTRODUCTION

The value of degree-days is a measure used to indicate the demand for energy to heat or cool buildings. The monthly and/or annual cooling and heating requirements of specific buildings in different locations can be estimated by means of the degree-days concept. The method assumes that the energy needs for a building are proportional to the difference between the mean daily temperature and a base temperature. The base temperature is the outdoor temperature below or above which heating or cooling is needed.

Energy analysis plays an important role in developing an optimum and cost effective design of HVAC system for a building. Orhan Buyukalaca *et al.* [3] determined the heating and cooling degree days for Turkey by using long term recent measured data. Viorel Badescu *et al.* [4] tested five models of computing degree day numbers and the most accurate method has been used to evaluate heating degree days for 29 Romanian localities. Sarak H *et al.* [5] determined the heating degree day method to determine natural gas consumption by residential heating in Turkey. Christenson M *et al.* [6] investigated the impact of climate warming on Swiss building energy demand was by means of the degree days method. India's climate could become warmer under conditions of increased atmospheric carbon dioxide. Lonergan [7] predicted the average temperature change to be in the range of 2.33°C to 4.78°C with a doubling in CO<sub>2</sub> concentrations.

With the enactment of Energy Conservation Act-2001, the Energy Management and Energy Conservation have become core issues in India. In 2002, Government of India set a target for reduction of energy conservation by 30% in government buildings, during the next five years. When establishing the baseline performance indices, space temperature inside the room should be considered as 23-26°C. [V P Gupta[8]]

The literature collected indicates that the cooling degree day calculation will be helpful for India to fix building energy standards. This present work considers Tiruchirappalli one of the hottest region of India for the cooling degree day analysis.

#### 1.1. Tiruchirappalli

Tiruchirappalli district is located at the Central part of TamilNadu, a southern state of India. Figure [1] shows the location of Tiruchirappalli in India and it indicates that it is one of the hottest region in India.

Area : 4,403.83 (Sq.Km.)  
 North Latitude : Between 10° to 11° 30'  
 East Longitude : Between 77° 45' to 78° 50'  
 Altitude : 78 metres

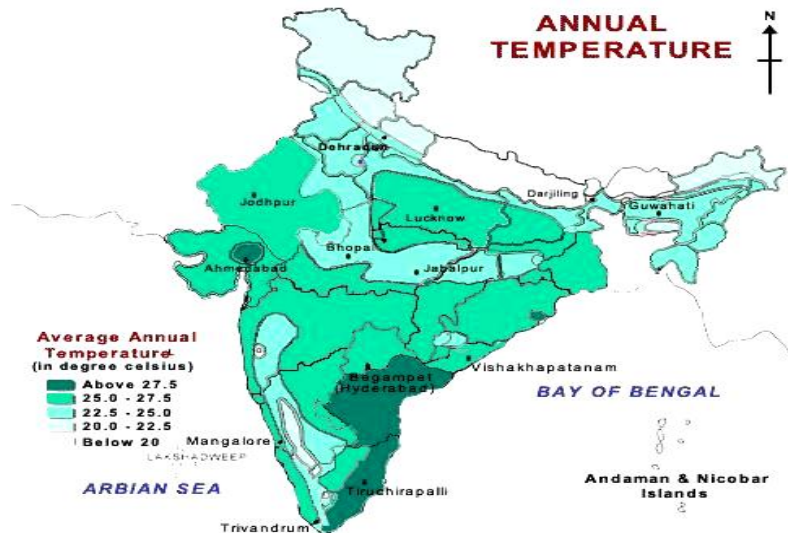


Figure 1. Annual Temperature in India

The variation of temperature through out the year exhibits hot and dry climate with high temperature and low degree of humidity. The region experiences four main seasons:

- Cool Months - December to February
- Hot Months - March to May
- Windy Months - June to August and
- Rainy Months - September to November

Temperature Summer : Max. 42°C , Min. 28.4°C

Winter : Max. 31.3°C, Min. 20.6°C.

Figure[2] shows the temperature variations in Tiruchirappalli.

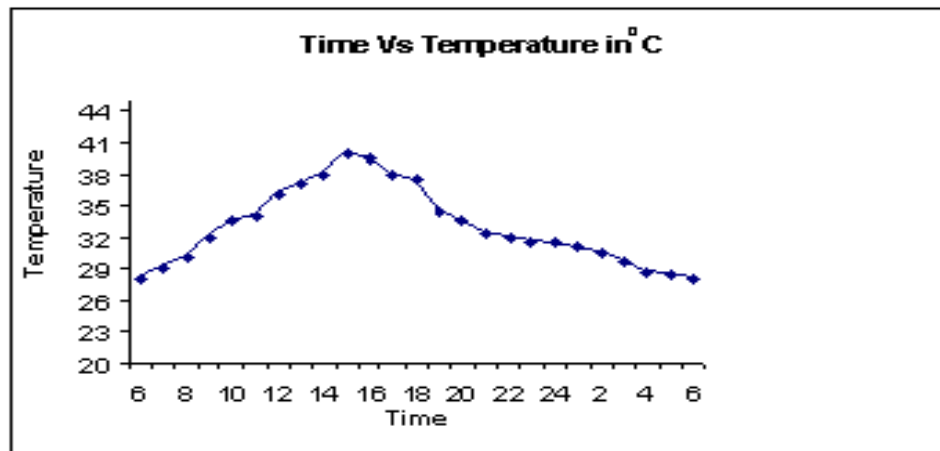


Figure 2. Outside temperature with time in Tiruchirappalli

**1.2. Concept Of Heating And Cooling Degree Days**

A “degree day” is a measure of the average temperature’s departure from a human comfort level of 18 °C (65 °F). The concept of degree days is used primarily to evaluate energy demand for heating and cooling services. Using a base temperature of 18 °C, heating degree days (HDDs) are defined as 18 – T, where T is the average temperature of

a given day. Thus, a day with an average temperature of 10 °C will have 8 degree heating days. Cooling degree days (CDDs) are calculated in a similar fashion. Cooling degree days are defined as  $T - 18$ , where  $T$  is the average temperature. Accordingly, a day with an average temperature of 25 °C will have 7 degree cooling days. For both heating and cooling degree days, average temperature of a particular day is calculated by adding the daily high and low temperatures and dividing by two. [Kevin Baumert *et al.*[11]]

### 1.3. Computation Of Degree Days

The calculation requires daily measurements of maximum and minimum outside air temperatures ( $T_{max}$  and  $T_{min}$ ) and a 'base temperature'  $T_{base}$ , nominated by the user as an estimate of the outside air temperature at which no artificial heating (or cooling) is required. The degree-day figure for a given month or week is the accumulated total of daily results over the period in question. The daily result for **heating** degree days,  $D_h$ , is selected from the following formulae:

Condition	Formula used
$T_{max} < T_{base}$	$D_h = T_{base} - (T_{max} + T_{min}) / 2$
$T_{max} > = T_{base}$	$D_h = (T_{base} - T_{min}) / 2 - (T_{max} - T_{base}) / 4$
$(T_{max} + T_{min}) / 2 > T_{base}$	$D_h = (T_{base} - T_{min}) / 4$
$T_{min} > T_{base}$	$D_h = 0$

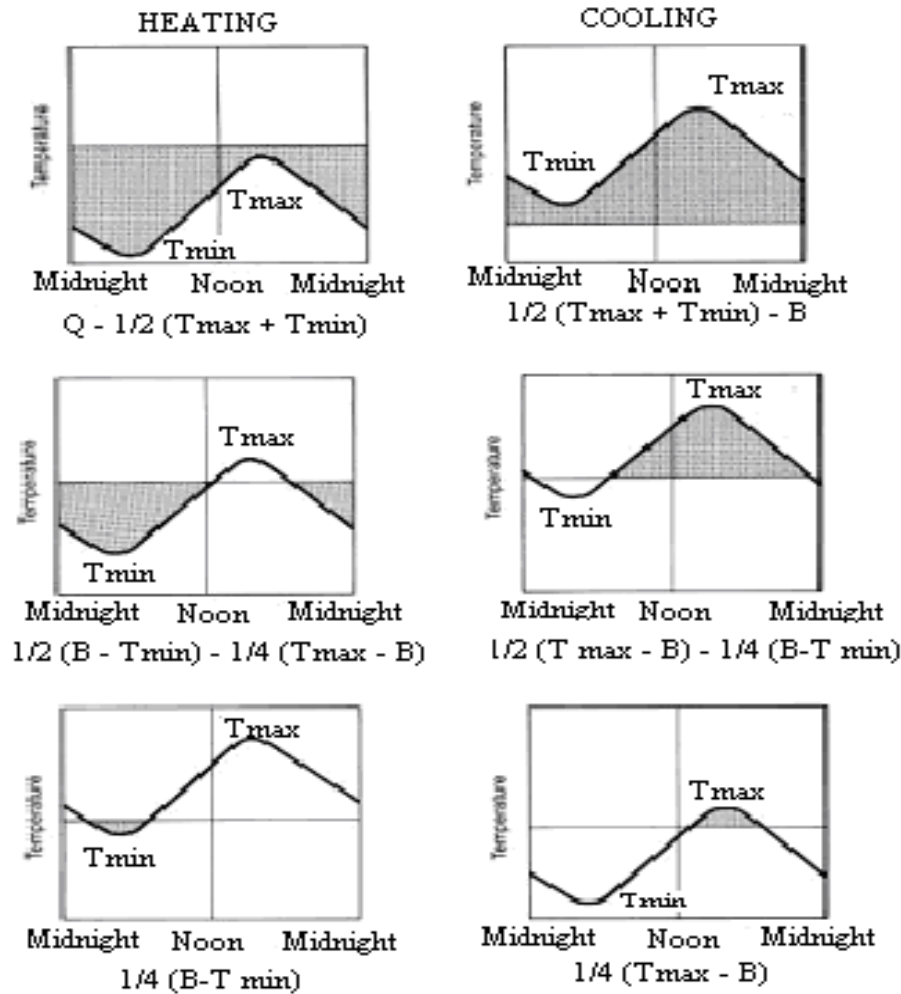
The daily result for **cooling** degree days,  $D_c$ , is selected from the following formulae:

Condition	Formula used
$T_{min} > T_{base}$	$D_c = (T_{max} + T_{min}) / 2 - T_{base}$
$T_{min} < = T_{base}$	$D_c = (T_{max} - T_{base}) / 2 - (T_{base} - T_{min}) / 4$
$(T_{max} + T_{min}) / 2 < T_{base}$	$D_c = (T_{max} - T_{base}) / 4$
$T_{max} < T_{base}$	$D_c = 0$

where

- $T_{base}$  = Base Temperature (°C)
- $T_{max}$  = Daily maximum temperature (°C)
- $T_{min}$  = Daily minimum temperature (°C)
- $D_h$  = Heating degree days
- $D_c$  = Cooling degree days

Figure[3] shows the graphical representation of formula used for calculation of heating and cooling degree days.



Key: B = Base Temperature (°C)  
 T<sub>max</sub> = Daily maximum temperature (°C)  
 T<sub>min</sub> = Daily minimum temperature (°C)

Figure 3 .Degree day Formula

**1.4. Database For Temperature**

Accurate and reliable weather data are crucial for building energy simulations and analyses. The weather data being used in energy analysis determines the accuracy and characteristics of the results. Therefore, the database used in an energy analysis should cover a long period and depend on recent values .In this study, daily minimum and maximum outdoor dry-bulb temperatures of recent years were used. The data obtained during at least 6 years were used in the calculations. Daily mean temperatures were obtained by averaging the minimum and the maximum temperatures.

**2. RESULTS AND DISCUSSION**

Cooling Degree-day formula are used for calculating the degree days. The daily cooling degree-days is calculated using the corresponding formula according to the relation between minimum, maximum and base temperature using Excel spread sheets.

Table 1 to 11 shows the results of the spread sheets of monthly cooling degree days for base temperatures of 18,19,20,21,22,23,24,25,26,27 and 28 °C respectively.

Table 12 shows the average (2000 – 2005) annual cooling degree days for different base temperatures of 18,19,20,21,22,23,24,25,26, 27 and 28 °C.This indicates that 4.5 times increase in cooling degree days is noticed when varying the basetemperature from 28 °C to 18 °C.

Table 1. Cooling Degree days at base temperature 18°C for Tiruchirappalli

Year	2000	2001	2002	2003	2004	2005	Average
Month	Base 18°C						
January	224.45	232.3	255.375	249.05	231.75	249.25	240.36
February	280.5	268.65	232	286.8	260.85	264.65	265.58
March	347.4	365.65	358	367	363.7	378.2	363.33
April	416.25	382.5	426.15	426.75	442.4	376.8	411.81
May	435.1	459.2	446.1	440.2	384.05	442.6	434.54
June	386	398.75	394.15	425.85	392.85	435.65	405.54
July	404.8	416.05	436.25	393.65	388.75	425.1	410.77
August	353.3	391.8	415.8	372.85	411.15	417.35	393.71
September	336.1	357.8	401	378	336.6	367.5	362.83
October	316.1	319.85	332.4	318.4	304	321.85	318.77
November	261.9	264.8	270.85	239.55	240.4	231	251.42
December	207.025	226.5	252.625	239.15	233.45	235.15	232.32
Annual CDD	3968.925	4083.85	4220.7	4137.25	3989.95	4145.1	4090.96

Table 2. Cooling Degree days at base temperature 19°C for Tiruchirappalli

Year	2000	2001	2002	2003	2004	2005	Average
Month	Base 19°C						
January	193.70	201.30	225.50	218.15	202.35	218.70	209.95
February	251.63	240.95	204.15	258.80	231.95	236.88	237.39
March	316.40	334.65	327.00	336.00	332.85	347.20	332.35
April	386.25	352.50	396.15	396.75	412.40	346.80	381.81
May	404.10	428.20	415.10	409.20	353.05	411.60	403.54
June	356.00	368.75	364.15	395.85	362.85	405.65	375.54
July	373.80	385.05	405.25	362.65	357.75	394.10	379.77
August	322.30	360.80	384.80	341.85	380.15	386.35	362.71
September	306.10	327.80	371.00	348.00	306.60	337.50	332.83
October	285.10	288.85	301.40	287.40	273.00	290.85	287.77
November	232.15	234.80	240.85	209.55	210.40	201.00	221.46
December	177.00	195.95	221.93	208.90	202.45	204.15	201.73
Annual CDD	3604.53	3719.60	3857.28	3773.10	3625.80	3780.78	3726.85

Table 3. Cooling Degree days at base temperature 20 °C for Tiruchirappalli

Year	2000	2001	2002	2003	2004	2005	Average
Month	Base20 °C						
January	163.775	170.725	195.85	187.95	174.7	188.875	180.31
February	223.05	214.425	176.475	230.8	204.675	209.675	209.85
March	285.525	303.65	296	305	302.425	316.2	301.47
April	356.25	322.5	366.15	366.75	382.4	316.8	351.81
May	373.1	397.2	384.1	378.3	322.05	380.6	372.56
June	326	338.75	334.15	365.85	332.85	375.65	345.54
July	342.8	354.05	374.25	331.65	326.75	363.1	348.77
August	291.3	329.8	353.8	310.85	349.15	355.35	331.71
September	276.1	297.8	341	318	276.6	307.5	302.83
October	254.1	257.85	270.4	256.4	242	259.85	256.77
November	202.55	204.8	210.9	179.675	180.4	171.05	191.56
December	148.35	166.85	192.65	179.675	172.55	173.825	172.32
Annual CDD	3242.90	3358.40	3495.73	3410.90	3266.55	3418.48	3365.49

Table 4. Cooling Degree days at base temperature 21°C for Tiruchirappalli

Year	2000	2001	2002	2003	2004	2005	Average
Month	Base21 °C						
January	135.5	142.175	160.525	160.1	148.075	160.525	151.15
February	194.55	188.775	184.4	203.025	180.175	184.4	189.22
March	255.4	272.725	285.45	274.225	273.1	285.45	274.39
April	326.25	292.5	286.8	336.75	352.4	286.8	313.58
May	342.1	366.2	349.6	347.55	291.05	349.6	341.02
June	296	308.75	345.65	335.85	302.85	345.65	322.46
July	311.8	323.05	332.1	300.65	295.75	332.1	315.91
August	260.3	298.8	324.35	279.85	318.15	324.35	300.97
September	246.1	267.8	277.5	288	246.6	277.5	267.25
October	223.325	226.85	228.85	225.4	211	228.85	224.05
November	173.3	174.825	141.9	149.925	150.525	141.9	155.40
December	121.25	138.525	144.625	151.675	144.2	144.625	140.82
Annual CDD	2885.875	3000.975	3061.75	3053	2913.875	3061.75	2996.20

Table 5. Cooling Degree days at base temperature 22 °C for Tiruchirappalli

Year	2000	2001	2002	2003	2004	2005	Average
Month	Base22 °C						
January	109.025	115.5	139.4	134.375	122.6	134.025	125.82
February	166.95	163.775	124.9	176.05	156.825	160.55	158.18
March	225.5	242.625	235.225	244.2	244.1	255.375	241.17
April	296.25	262.5	306.15	306.75	322.4	256.8	291.81
May	311.1	335.2	322.1	316.85	260.05	318.6	310.65
June	266	278.75	274.15	305.85	272.85	315.65	285.54
July	280.85	292.25	312.25	269.65	264.75	301.1	286.81
August	229.3	267.8	291.8	248.85	287.15	293.35	269.71
September	216.15	237.8	281	258	216.6	247.5	242.84
October	192.7	195.85	208.4	194.575	180	197.85	194.90
November	144.7	146.05	152.1	121	121.375	113.725	133.16
December	95.775	110.9	139.9	125	117.3	116.4	117.55
Annual CDD	2534.30	2649.00	2787.38	2701.15	2566.00	2710.93	2658.13

Table 6 . Cooling Degree days at base temperature 23 °C for Tiruchirappalli

Year	2000	2001	2002	2003	2004	2005	Average
Month	Base 23 °C						
January	85.15	90.80	113.90	110.28	98.65	109.25	101.34
February	140.13	139.33	103.00	150.90	134.08	137.75	134.20
March	196.45	214.28	207.08	215.28	215.85	225.95	212.48
April	266.48	232.63	276.15	276.75	292.40	227.00	261.90
May	280.33	304.50	291.13	286.73	229.13	287.70	279.92
June	236.00	248.75	244.15	275.85	242.85	285.65	255.54
July	250.43	261.50	281.25	238.65	233.78	270.10	255.95
August	198.48	236.85	260.80	217.98	256.15	262.35	238.77
September	186.63	208.08	251.00	228.18	186.60	217.50	213.00
October	162.63	165.03	177.53	164.33	149.80	167.60	164.48
November	117.35	118.83	123.90	94.80	93.85	86.60	105.89
December	71.80	85.98	115.28	100.45	91.73	89.75	92.50
Annual CDD	2191.83	2306.53	2445.15	2360.15	2224.85	2367.20	2315.95

Table 7. Cooling Degree days at base temperature 24 °C for Tiruchirappalli

Year	2000	2001	2002	2003	2004	2005	Average
Month	Base 24 °C						
January	61.90	67.33	91.05	86.88	75.83	85.95	78.15
February	115.65	116.68	82.70	127.73	111.73	115.80	111.71
March	168.75	187.90	180.23	187.78	189.50	197.08	185.20
April	236.90	203.23	246.15	246.75	262.48	197.38	232.15
May	250.18	274.00	260.40	256.90	198.78	257.23	249.58
June	206.00	218.75	214.63	246.23	212.85	255.65	225.68
July	220.43	231.03	250.25	207.95	203.25	239.23	225.35
August	168.20	206.10	229.90	187.83	225.15	231.48	208.11
September	158.43	179.23	221.45	198.88	157.93	188.05	183.99
October	134.38	135.55	148.10	135.60	121.38	138.80	135.63
November	93.03	93.85	97.50	71.73	70.35	61.95	81.40
December	50.63	62.90	91.98	77.70	67.78	66.63	69.60
Annual CDD	1864.45	1976.53	2114.33	2031.93	1896.98	2035.20	1986.57

Table 8. Cooling Degree days at base temperature 25°C for Tiruchirappalli

Year	2000	2001	2002	2003	2004	2005	Average
Month	Base 25 °C						
January	40.40	45.45	70.63	63.85	56.78	63.73	56.80
February	93.60	95.53	63.08	105.93	89.73	94.75	90.43
March	143.30	162.25	154.30	161.30	164.23	169.73	159.18
April	207.40	174.75	216.23	217.48	233.05	168.50	202.90
May	220.48	243.50	229.95	227.45	169.43	227.53	219.72
June	176.00	189.18	185.45	216.83	183.13	225.65	196.04
July	190.50	200.93	219.48	178.08	173.05	208.90	195.15
August	139.65	175.83	199.20	159.48	194.30	201.33	178.30
September	132.45	151.93	192.58	171.08	131.68	160.00	156.62
October	109.30	109.15	121.00	110.78	96.43	112.65	109.88
November	71.03	70.95	74.78	50.25	49.38	41.88	59.71
December	36.30	42.45	69.85	57.28	46.70	47.00	49.93
Annual CDD	1560.40	1661.88	1796.50	1719.75	1587.85	1721.63	1674.67



Table 9: Cooling Degree days at base temperature 26 °C for Tiruchirappalli

Year	2000	2001	2002	2003	2004	2005	Average
Month	Base26 °C						
January	27.60	30.53	52.20	43.43	43.15	45.73	40.44
February	72.85	75.20	45.73	84.73	68.30	74.03	70.14
March	119.75	137.08	129.38	136.65	140.08	143.63	134.43
April	178.93	147.95	187.03	189.40	204.05	140.75	174.68
May	191.78	213.35	200.25	198.38	141.85	198.68	190.71
June	147.10	160.50	157.25	188.00	154.93	195.85	167.27
July	161.83	171.25	188.80	149.58	144.40	179.00	165.81
August	114.20	147.38	168.95	132.85	164.18	172.48	150.00
September	108.75	126.90	165.40	146.53	107.78	134.10	131.58
October	85.90	85.13	96.93	87.43	74.58	89.25	86.53
November	52.08	50.20	54.10	33.20	31.55	27.20	41.39
December	25.43	28.38	54.75	41.10	31.25	31.95	35.48
Annual CDD	1286.18	1373.83	1500.75	1431.25	1306.08	1432.63	1388.45

Table 10. Cooling Degree days at base temperature 27 °C for Tiruchirappalli

Year	2000	2001	2002	2003	2004	2005	Average
Month	Base 27 °C						
January	19.40	21.13	37.25	32.25	31.13	32.55	28.95
February	53.08	58.55	31.55	64.23	51.15	55.95	52.42
March	97.03	113.15	105.75	113.35	117.10	118.95	110.89
April	153.03	124.28	160.85	163.38	176.23	115.65	148.90
May	164.33	184.63	171.85	170.03	116.05	170.75	162.94
June	121.53	133.90	131.80	161.10	129.48	166.95	140.79
July	135.88	143.50	159.73	123.78	118.43	150.58	138.65
August	90.78	122.25	141.90	108.73	137.25	145.15	124.34
September	86.15	104.18	141.43	123.93	85.33	110.78	108.63
October	63.15	63.83	74.20	64.65	54.38	67.58	64.63
November	34.93	33.73	36.45	21.08	19.30	17.40	27.15
December	16.98	19.55	43.33	28.95	21.00	20.65	25.08
Annual CDD	1036.23	1122.65	1236.08	1175.43	1056.80	1172.93	1133.35

Table 11. Cooling Degree-days at base temperature 28 °C for Tiruchirappalli

Year	2000	2001	2002	2003	2004	2005	Average
Month	Base 28 °C						
January	12.00	13.18	25.88	24.35	22.05	23.08	20.09
February	37.58	44.35	23.85	46.40	40.05	41.80	39.00
March	76.03	91.23	83.25	90.83	96.25	95.90	88.91
April	129.98	101.98	138.05	139.78	151.50	94.28	125.93
May	139.93	158.35	146.20	143.63	93.80	144.25	137.69
June	98.93	110.83	108.83	137.68	106.53	140.95	117.29
July	111.98	119.68	135.58	99.85	95.10	125.28	114.58
August	67.58	99.15	118.60	85.68	113.98	120.95	100.99
September	64.73	81.83	118.85	101.43	65.25	88.03	86.68
October	42.88	44.33	53.35	44.90	38.18	47.53	45.19
November	22.60	21.58	24.20	13.35	11.88	10.08	17.28
December	10.23	12.55	33.45	20.30	13.15	12.00	16.95
Annual CDD	814.40	899.00	1010.08	948.15	847.70	944.10	910.57

Table 12. Average Annual Cooling Degree days

	Base 18	Base 19	Base 20	Base 21	Base 22	Base 23	Base 24	Base 25	Base 26	Base 27	Base 28
<b>Jan</b>	239.34	208.82	179.15	151.15	124.93	100.56	77.30	55.65	39.36	28.95	20.09
<b>Feb</b>	271.02	242.85	215.38	189.22	164.12	139.99	117.23	95.71	74.85	52.42	39.00
<b>Mar</b>	366.69	335.72	304.83	274.39	244.53	215.63	188.01	161.75	136.80	110.89	88.91
<b>Apr</b>	403.58	373.58	343.58	313.58	283.58	253.71	224.02	194.95	166.97	148.90	125.93
<b>May</b>	433.96	402.96	371.98	341.02	310.07	279.35	249.05	219.32	190.45	162.94	137.69
<b>Jun</b>	412.46	382.46	352.46	322.46	292.46	262.46	232.52	202.74	173.70	140.79	117.29
<b>Jul</b>	408.91	377.91	346.91	315.91	284.95	254.09	223.52	193.39	164.18	138.65	114.58
<b>Aug</b>	393.97	362.97	331.97	300.97	269.97	239.03	208.37	178.65	150.59	124.34	100.99
<b>Sep</b>	357.25	327.25	297.25	267.25	237.26	207.41	178.43	151.19	126.36	108.63	86.68
<b>Oct</b>	317.01	286.01	255.01	224.05	193.14	162.83	134.08	108.49	85.25	64.63	45.19
<b>Nov</b>	244.78	214.82	184.92	155.40	126.76	99.67	75.48	54.23	36.90	27.15	17.28
<b>Dec</b>	229.40	198.77	169.18	140.82	113.63	88.24	65.38	46.12	31.68	25.08	16.95
<b>Annual CDD</b>	4078.4	3714.1	3352.6	2996.2	2645.4	2302.9	1973.4	1662.2	1377.1	1133.4	910.57

Figure[4] indicates the variation of average monthly cooling degree days with months for base temperature 28°C.

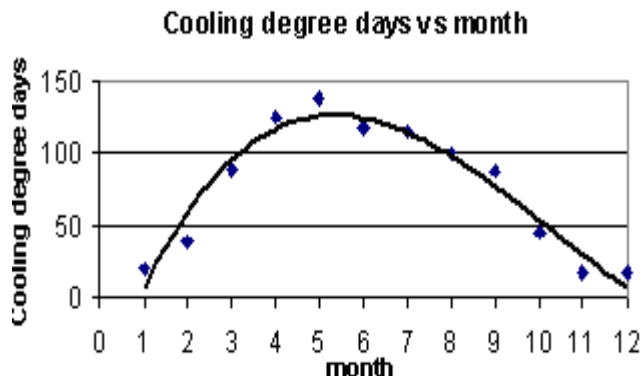


Figure 4. Variation of average monthly cooling degree-days with month

The relation is found to be

$$y = 0.3337 x^3 - 10.273 x^2 + 81.194x - 64.658 \quad R^2 = 0.9419 \quad (1)$$

Where x =Month Number (i.e.) January =1,February=2,.....December=12.

y=Monthly average cooling degree days.

Figure [5] shows Variation of cooling degree days with different months for base temperatures of 18° C to 28° C CDD with different months with different base temperature.

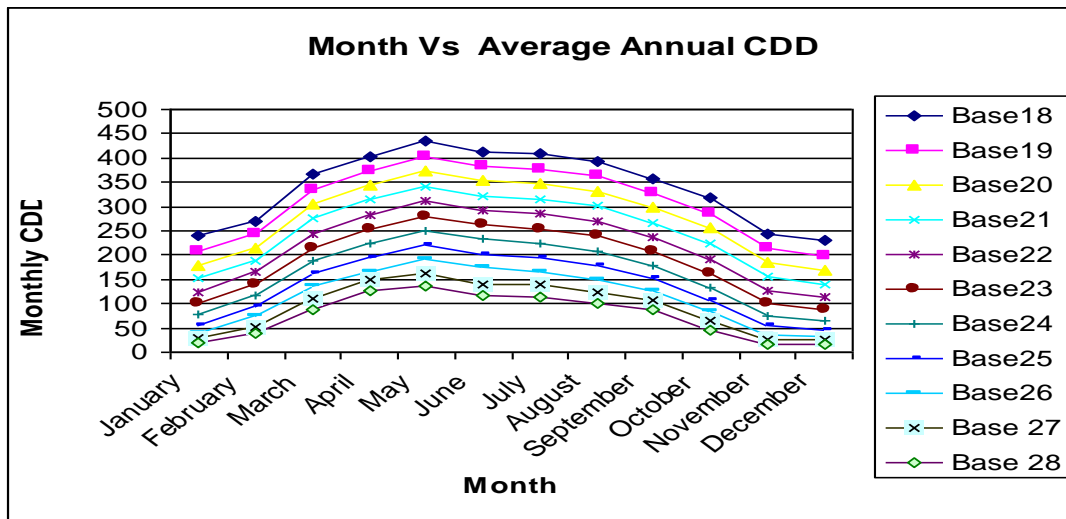


Figure 5 . Variation of CDD with different months with different base temperature

Figure [6] shows the relation between annual cooling degree days and base temperature for Triuchirapalli.

Following equation represents the Figure [6]

$$Y = -322.08X + 9784.7 \quad R^2 = 0.9952 \quad (2)$$

Where Y=Annual cooling degree days.

X=Base temperature (18° C to 28° C)

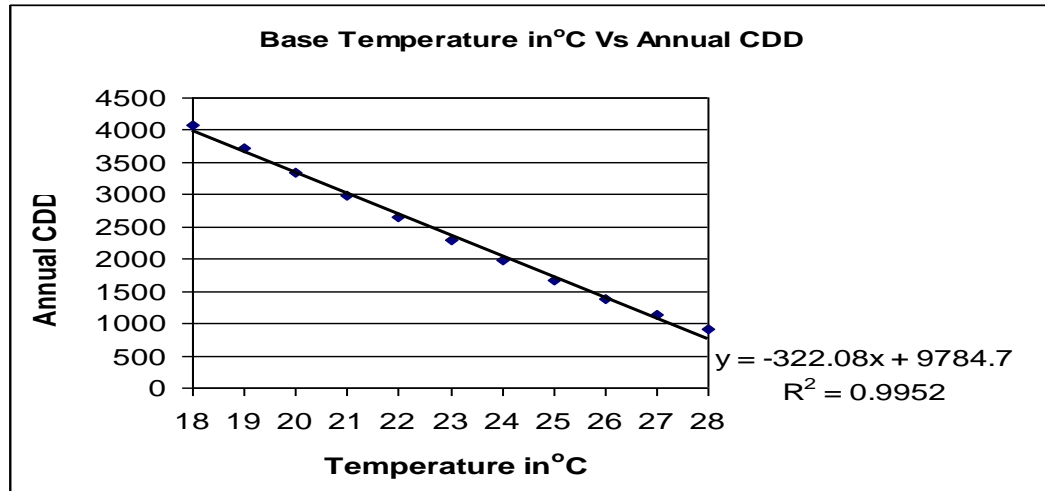


Figure 6. Variation of yearly cooling degree days with different base temperature for Tiruchirappalli

**2.1. Energy Loss Calculation**

**Fabric Loss**

The U-value of a material or structure is the rate at which heat will pass through a given area for a given temperature difference. It is a property of the material in a structure and is usually measured in watts per square metre per degree Celsius (W/m<sup>2</sup> /°C).

$$\text{Cooling Energy Lost} = \frac{U * \text{Annual CDD} * 24}{1000} \text{ kWh/year/m}^2$$

The specification of walls, roofs in India and their U values are given in Appendix I & Appendix II respectively.

Base temperature = 18<sup>o</sup>C then annual cooling degree days = 4078.36

If minimum U value of .8W/m<sup>2</sup>/°C is considered for walls then cooling Energy loss = 78.3 kWh/year/m<sup>2</sup>.

If maximum of U value of wall 4.12 W/°C is considered cooling energy loss is 403.3 kWh/year/m<sup>2</sup>.

No. of units saved per year/m<sup>2</sup> = 325. Percentage savings in energy is 80.6.

Table: 13 Indicates the energy that could be saved at different base temperature by going for the best U value material for construction.

Table 13. Effect of U value on Energy Loss

Base Temp(°C)	CDD	Energy loss With U= 0.8	Energy Loss with U= 4.12	Energy saved kWh / year/m <sup>2</sup>
18	4078.36	78.30	403.27	325
19	3714.1	71.31	367.25	295.94
20	3352.62	64.37	331.51	267.14
21	2996.2	57.53	296.26	238.77
22	2645.38	50.79	261.58	210.79
23	2302.96	44.22	227.72	183.5
24	1973.38	37.89	195.13	157.24
25	1662.19	31.91	164.36	132.35
26	1377.1	26.44	136.17	109.73
27	1133.35	21.76	112.07	90.31
28	910.57	17.48	90.04	72.56

**2.2. Proper Base Temperature**

Although it is widely accepted, where possible, an appropriate base temperature for degree days should be selected with regard to the application concerned, and the best way to deal with occupancy and other correction to alter the base temperature

Base temperature = 18°C    Cooling Degree days 40784  
 Base temperature =28°C    Cooling degree days=910.6  
 If U value considered    = 0.8 W/m<sup>2</sup>/°C  
 Energy loss at 18°C    = 78.30 kWh/year/m<sup>2</sup>  
 Energy Loss at 28°C    = 17.48 kWh/year/m<sup>2</sup>  
 Percentage Energy savings = 77.7

Table: 14 Indicates the Energy loss calculated for various base temperatures.

Table14. Effect of Base temperature on Energy Loss

Base Temp (°C)	CDD	Energy loss KWh/year/m <sup>2</sup>	Energy Loss if base temp = 28 °C KWh/year/m <sup>2</sup>	Energy savings
18	4078.36	78.30	17.48	77.67
19	3714.1	71.31	17.48	75.48
20	3352.62	64.37	17.48	72.84
21	2996.2	57.53	17.48	69.61
22	2645.38	50.79	17.48	65.58
23	2302.96	44.22	17.48	60.46
24	1973.38	37.89	17.48	53.86
25	1662.19	31.91	17.48	45.22
26	1377.1	26.44	17.48	33.88
27	1133.35	21.76	17.48	19.66
28	910.57	17.48	17.48	0.00

### 3. CONCLUSION

The impact of cooling degree days on building design parameters for computing energy demand for cooling was investigated in this study. The cooling degree-days with variable-base temperatures for Tiruchirappalli are determined using long-term measured data. Base temperatures of 18,19,20,21,22,23,24,25,26,27 and 28 °C are chosen in the calculation of cooling degree-days. Yearly cooling degree-days are given in tabular forms for Tiruchirappalli. Average annual cooling degree day is related with the base temperature with a correlation coefficient of 0.995. Calculations are also made to show the effect of base temperature and material of construction on energy savings.

### 4. ACKNOWLEDGEMENTS

The authors wish to express their gratitude to Meteorology station at Tiruchirappalli for providing all the data and NIT,Tiruchirappalli for providing all the facilities for carrying out this work.

### 5. REFERENCES

- [1]. ASHARE Hand book, Fundamentals (SI).Energy estimating Methods (chapter 28);1993.
- [2]. Said SAM, Degree-day base temperature for residential building energy prediction in Saudi Arabia.
- [3]. ASHRAE Transactions 1992;98(1):346-353. Orhan Buyukalaca, Husamettin Bulut, Tuncay Yılmaz. Analysis of variable-base heating and cooling degree- days for Turkey. Applied Energy 69 (2001): 269–283.
- [4]. Viorel Badescu , Elena Zamfir, Degree-days,degree-hours and ambient temperature bin data from monthly-average temperatures (Romania). Energy Conversion &Management 40 (1999): 885-900.
- [5]. Sarak H, Satman A, The degree-day method to estimate the residential heating natural gas consumption in Turkey: a case study. Energy 28 (2003): 929–939.
- [6]. Christenson M, Manz H , Gyalistras D., Climate warming impact on degree-days and building energy Demand in Switzerland .Energy Conversion and Management 47(2006) : 671–686.
- [7]. Lonergan S. 1998 Climate warming and India, Measuring the Impact of Climate Change on Indian Agriculture,edited by A Dinar, et al. Washington DC: World Bank. [World Bank Technical Paper No. 402].
- [8]. V P Gupta, Energy Conservation Strategies For Hvac Systems,www.electricalzone-bsnldelhi.com
- [9]. Meteorological Department, Tiruchirappalli [http://www.airportsindia.org.in/aii/all\\_airport-new.htm](http://www.airportsindia.org.in/aii/all_airport-new.htm)
- [10]. <http://www.iwmi.cgiar.org> climate data
- [11]. Kevin Baumert and Mindy Selman, Heating and Cooling Degree Days. World Resources Institute; 2003.
- [12]. Degree days, Fuel Efficiency booklet 7,Department of Environment, Energy Efficiency office, BRECSU, 1993.
- [13]. Bureau of Indian standards (parts 1-4): Handbook on Functional Requirements of Buildings (other than Industrial Buildings).